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Feasibility of Commercial Fishing Operations in the Mid-Atlantic Continental Slope

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FINAL REPORT

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PROJECT DESCRIPTION

Introduction

The fisheries in the United States have undergone tremendous changes in the past seven years. Many of these changes have resulted from the implementation of the Fisheries Conservation and Management Act of 1976 which created a 200 mile Fisheries Conservation and Management Zone (FCZ) contiguous to the coast line of the United States. Recognizing the fact that a large percentage of the fisheries resources in this zone were being exploited by foreign fishing fleets, Congress created the FCZ to give U.S. fishermen an opportunity to utilize a greater portion of the fish stock found within 200 miles of the U.S. coast.

The offshore fishing fleet of Virginia has undergone significant change during the past several years. Prior to 1976 approximately 90 vessels were operating out of Virginia ports. Of these, (84) operated as trawlers for finfish and the remainder operated sea scallop dredges. By 1980, this number had increased to over 200 vessels with the majority (115) operating primarily as scallop vessels rather than finfish trawlers. The growth in the number of vessels and shoreside facilities was prompted by an unusually large crop of sea scallops from Virginia to New England. The 1980 value of sea scallops landed in Virginia exceeded $24,000,000. Other factors involved in the growth of the offshore fishing industry included the implementation of the Fisheries Management and Conservation Act of 1976; a decrease in the level of foreign fishing and the availability of capital through lending programs sponsored by the U.S. Government.

The decline of the sea scallops stocks became evident with decreased landings and the decline of financing assistance for vessels and shoreside facilities. By 1982, less than 90 offshore vessels were landing in Virginia and the value of sea scallop landings dropped to \$8,400,000. Recently, due to a moderation in vessel operating costs, increasing ex-vessel prices of finfish and scallops and new opportunities with joint foreign fishing ventures for squid, mackerel and butterfish, a period of stability has allowed the fishing industry to look for new opportunities for growth and development.

Traditionally the winter season, November-March in the mid-Atlantic region, has been a period for harvesting primarily between the 15 to 100 fm contours. NMFS statistics for the region show that scup, fluke, black bass and trout are the major species being landed.

One area of consideration for fisheries development has been the exploitation of fish stocks on the continental slope of the mid Atlantic region at a depth of 100 - 300 fm. This area has not been considered as a popular fishing ground because of constraints in fishing operations due to weather and technical problems associated with deep-water fishing.

However, new opportunities must be explored if the mid Atlantic region is to develop the potential for a year-round fishery to employ the large number of offshore trawlers now working out of Hampton Roads proper and other ports from Cape May N.J. to Wanchese N.C. The basic premise of this project was to explore an alternate opportunity for fishing trawlers to harvest fish stocks during the winter months. This report, in addition to supplying catch data and other technically pertinent information, will provide an objective evaluation on all of the fishing gear, electronics, weather conditions, marketing strategies and fishing plans that were an essential part of the project. The report will assess the positive and negative aspects of the project and provide recommendations for future winter fishing endeavours on the slope.

Objectives

The objective of the project was to test the feasibility of conducting commercial trawling operations in the slope waters (100 fm-300 fm) adjacent to the traditional fishing areas on the continental shelf in the Mid-Atlantic Bight. This was to be accomplished by developing a fishing strategy that would be structured around existing information on stock abundance, type and location and implementing the fishing strategy by procuring a lease on a commercial fishing vessel that would be suitable for slope trawling. The implementation of fishery operations would be the primary goal of the project and every effort would be made to conduct the exploratory trips as a commercial trawling endeavour.

The tasks to be performed included; 1) conduct an analysis of existing data bases prior to the commencement of trawling operations. Anticipated catch rates by weight would be profiled for each species with commercial potential, with respect to season, depth and location. Based on the above analysis a plan for trawling operation would be constructed to provide information on optimum trawling times, location and depth; 2) develop economic profiles to assess the commercial feasibility of using existing commercial vessels for deep water trawling; 3) assess the capital costs of refitting existing vessels to enter the fishery by documenting the costs from information supplied from vessel owners, operators, marine railways, and manufacturers; 4) combine the projected revenues and costs associated with the conversion to deep water trawling to estimate net profitability and investment pay back periods; 5) determine the amount of decreased and increased costs as well as the amount of increased and decreased revenue associated with deep water conversion; 6) evaluate all fishing gear, nets, doors, electronics, hydraulics and machinery necessary for successful deep water trawling, as well as document any modifications that were made to existing gear and 7) assess the impact of weather on vessel operations and net profitability in the deep water environment.

The main objective throughout the project was to conduct all fishing operations as they would be conducted in a commercial fishing venture. Previous research projects focused on traditional scientific sampling methods, i.e. random sampling at predetermined stations. It was determined that the primary goal of the deep water trawling project should be to locate and harvest commercially viable fish stocks. Any effort to follow traditional scientific random sampling schemes would be a secondary consideration. Most, if not all of the objectives of the study were accomplished and all of them are addressed in this report.

<u>Fishing Plan</u>

A fishery plan was formulated that called for a leased vessel to fish the 100 fm-300 fm contour of the continental slope from Cape May, N.J. 35°N, 75°30'W x 39°N 74°30'W to Cape Hatteras, N.C. 35°N, 75°30'W x 35°N74°30'W. This area was divided into seven designated zones that were established by separating the area by 0°30' increments. All of the exploratory trawls were to be conducted between November and March, initiating in December of 1982 and terminating in January of 1984. The vessel captain once assigned to an area, would be able to fish anywhere along the slope he desired. Because weather and sea conditions on the slope are potentially more severe than shelf areas, the vessel would be allowed to come inside to trawl or jog in the event of inclement conditions. Since the project was simulating the economic and physical constraints trawlers are subject to, inshore fishing operations were conducted whenever it was economically feasible to steam to and from the shelf.

It was important that the vessel used for this project would reflect the majority of vessels comprising the mid-Atlantic deep water fleet. The vessel would be in the 75'-100' class, with a horsepower range of 400-800, be single rigged, with a stern ramp, Kort nozzel and net reel. The vessel would also have to be able to meet the following criteria:

1) Gear and sufficient wire to fish deeper than 200 fm.

2) The vessel would be in good working order prior to each trip. It would have to be inspected by the project coordinator to determine its state of readiness

3) A full complement of electronics in good working order to include: Loran C, Loran C track plotter, radar, radios, chromascope with low frequency capability (28Khz) and a paper recording echo sounder.

4) A captain and a sufficient number of crew to adequately handle the gear and vessel.

5) Detailed marketing information on the distribution, pricing and handling of the product would be supplied for evaluation.

A leasing strategy was developed that was in essence a "guarantee program". The project guaranteed all the fuel, ice, oil, captain and crew costs. In return for the guarantee, a percentage of the proceeds of the gross catch would be returned to the grant, which in turn would use the funds for more vessel time. The amount returned to the grant was determined by using a sliding scale that increased the projects percentage as the gross value was increased.

In December of 1982 the F/V Virginia Queen agreed to the terms of the lease and was contracted for the 1982-83 winter season, making three trips between January 17, 1983, and March 7, 1983 for a total of 21 days. In December of 1983 the F/V Virginia Cavalier was contracted for 15 days of exploratory deepwater trawling, making three trips totaling 15 days between Dec. 12, 1983 and Jan. 12, 1984.

The F/V Virginia Cavalier and the F/V Virginia Queen were sisterships equipped with identical power and equipment. The vessel guarantee program was changed to a straight lease program for the F/V Virginia Cavalier because the previous "guarantee" arrangement proved to be unworkable.

Plans conceived ashore for operations conducted at sea are generally subject to modification. Even the most detailed and thoughtfully conceived fishing plan cannot anticipate every condition and situation that may occur while harvesting offshore. The plan was designed to have the flexibility of being able to deal with the complications of deep water trawling on a day to day basis. However, it should be noted that no matter how much flexibility is designed into a trawling project, it is still a simulated effort that must integrate both the scientific and commercial interests. The plan called for trawls to be conducted in all seven zones which meant that there was a limit on how much time which could be allocated for finding large quantities of marketable species. This resulted in a situation called "blind setting."

A blind set is when a vessel captain must set his gear at a certain depth over previously unknown bottom and tow for a predetermined amount of time even when there is no apparent electronic indication of fish; a condition most trawler captains choose to avoid. This condition, although not always productive in the number of pounds per tow, was necessary to assess information on trawl performance, stock abundance, bottom conditions and overall vessel performance.

Vessel Specifications

The Virginia Queen and the Virginia Cavalier are sister ships that are western rigged multipurpose stern trawlers. Originally rigged for scalloping, the vessels which were equipped with stern ramps and net reels. They were converted over to ground fishing after the decline and collapse of the scallop stocks in the late seventies and early eighties. The vessels were constructed of steel by Quality Marine Inc. of Theodore, Alabama in 1977-78. Other than the complement of electronics the vessels are totally identical in power, deck machinery and layout. The vessels specifications are itemized below:

LENGTH 90'

Beam at amid ship 24'

Depth at amid ship 13'

Hull plating 5/16" 1/2 in. way of dredges

Keel 12" x 1" plate

Tanks 1/4 plate

Fuel tank cap. approx. 12,000 gals

Water tank cap. approx. 1300 gals

Hold cap. 5,800 cu. ft.

Pilot house and cabin 18' x 16'

Electrical system marine cable P-30 32 volt

Main propulsion 348 Catapillar 700 hp at 1800 RAM

Hydraulics Marco P.T.O.

Gear Twin Disc MG527, 5:17 to 1 reduction

Keel cooling (1) Fernstrum Model 1690

Instrument panel Mechanical in pilot house

Generators (2) 3304 Catapillar 30 KW

Propellor 4 blade bronze with kort nozzel

Batteries (1) bank of four light volt

Steering Hydraulic with two motors and two rams

Controls Morse mechanical

Mast "A" frame 8" pipe

Boom "A" frame 6" pipe

Fish hold Ice, bin boards 200,000 lb iced cap.

Fish hold insulation

Sides 6" polyurethane

Top and Bottom 6" polyurethane

Winches (2) Marco WT101

(2) Gearmatic cargo hoists

Stays Top, bow and hold back for (2) 40' outriggers

Stern ramp 8' wide with direct drive hydraulic net reel

Gallows 11' ft high on stern.

Vessel Electronics

Each vessel had the following complement of electronics:

Virginia Queen

(1) EPSCO C NAV loran, (1) Epsco C NAVXL loran, (1) INTERNAV 360-A and C loran, (2) Sitex Koden 32 mile radars, (1) CB radio, (1) AM-FM 40 channel courier, (1) Epsco chromoscope fish finder, (1) Hailer, (1) Sitex 400 fm paper recorder.

(1) Wesmar Auto pilot AP-1100 (1) Motorala VHF radio 75 channel, (1) Dubose - SSB200 - 10 channel radio (1) Data Marine sea temperature gauge. (1) Epsco C. Plot II loran plotter.

Virginia Cavalier

(1) Epsco CVS-886 chromoscope, (1) Wood Freeman model 500 autopilot, (1) Epsco C Plot II loran plotter, (1) Northstar 7000 loran, (1) Epsco C NAVXL loran, (2) Epsco 40 mile radars, (1) Sitex 500 fm Paper Recorder. (1) Dubose - SSB200 - 10 channel radio. (1) Raytheon 50 channel VHF radio. (1) Data Sea temperature gauge.

Nets, Gear, Doors and Machinery

Each vessel had the following complement of gear:

Virginia Queen

(1) Set of 10' wharf forge wooden doors, 2 Cape May high-rise nets (1) "41" Levine 10 dog net. (1) Levine flat fish net. (1) Set of Calvin Hudgins fabricated timken bearing trawl blocks. (1) Set of Marco WT-101 hydraulic winches with 475 fm of 3/4" 9x16 galvanized trawl cable (1) Set of 100 ft 3/4" ground cables. (1) Rodger Harris high rise squid net.

Virginia Cavalier

(1) Set of 10' Wharf Forge wooden doors, (1) Set of 11' ft wharf forge wooden doors. (2) Cape May high rise rope nets. (1)

"36" Levine flat net. (1) Set of Hathaway cast trawl blocks. (1) Set of Marco WT-101 hydraulic trawl winches with 500 fm of 3/4" 9 x 16 trawl wire (1) set of 3/4" 100 ft. ground cables.

Summary of Virginia Queen Trips 1982-1983

Three trips were conducted totaling 21 days on the grounds, but due to the severe weather conditions there were actually only 12 days when the vessel could effectively trawl on either the slope or the shelf areas. The duration and dates of each trip are as follows: (Trip #1) Jan 17, 1983 to Jan 2, 1983, 5 days, (Trip #2) Jan 24, 1983 to Feb 3, 1984, 10 days, (Trip #3) March 2, 1983 to March 7, 1983, 6 days. Gross catch consisted of 29,000 lbs of finfish and squid with a value of $9,888.00. A composite of the catch reveals that scup followed by black bass, squid, flounder, butterfish, bluefish, whiting and red hake as the most abundant species landed.

There were two major obstacles that the project confronted during this time frame: (1) extended periods of bad weather (3 to 5 days), and (2) a constant problem with spiny dogfish. A series of back to back "Nor Easters" (low pressure) were followed by the "Nor Westers" (high pressures) creating a situation of alternate periods of fishing and jogging in high winds and seas. Even after the winds and seas had subsided, the resulting ground swell prevented the doors from maintaining adequate bottom contact in the deep water; a condition that caused trawling operations to cease. It should be noted that it was during this period of weather that the collier Marine Electric was lost off the Virginia coast.

A continuing problem with spiny dogfish was a major obstacle in determining the depths and areas that could be fished with a minimum amount of damage to the gear. Large masses of dogfish were encountered from 50 fm to 270 fm in all seven fishing zones, with half hour tows yielding catches in excess of 30,000 pounds. Data taken from the trawls indicated that the deeper trawls caught smaller dogfish (12"-18") but the catch was greater. Large masses of spiny dogfish were electronically identified throughout the water column (chromoscope verification) causing some speculation that the dogfish were congregating for unknown reasons.

Every attempt was made with the electronics or with the benefit of Captain Rowe's forty years of experience to avoid making sets on large schools of dogfish. The Epsco Chromoscopes color indication for dogfish was a bright kelly green. This was confirmed by the correlation that every tow that would show broad bands of this color on the scope, would subsequently yield large catches of this species. On the tows that would yield small catches, the green color on the scope was noticeably absent. To obtain better results it became necessary to conduct a 20 to 30 minute tow prior to making the usual 1-1/2 - 2 hour trawl. This method, which is similar in theory to the tri-net concept, would generally provide an accurate estimate of the dogfish's presence in an area. This procedure was implemented to prevent the net from overloading on a long tow. This technique is particularly useful on the Cape May high-rise net, which has a long extension designed to handle 100,000 - 150,000 lbs. of fish.

As well as detecting large schools of dogfish, the electronics indicated that there were high concentrations of squid between the 100 fm - 300 fm contours, but were unharvestable due to their location in the water column. All of the schools that were observed were approximately 15 fm - 25 fm off the bottom and were approx 10 fm deep. Although positive identification can not be made with electronics and the demersal trawl gear could not harvest the squid, all of the dogfish that were caught and examined had been feeding on Loligo squid. This fact, though not totally conclusive, does provide evidence that Loligo squid were in the area. These concentrations, which were apparently significant, indicate (though this is speculative) that there is a potentially large harvestable biomass that could be harvested by employing midwater or offbottom trawling techniques.

The most productive tows during the three trips were in the Norfolk Canyon area. Tows conducted in the slope areas would consistently yield 3000-4000 pounds of small whiting and red hake. These species, which are generally regarded as trash fish, represent a potential fishery for the future. Two tows that were made on the Southeast corner of Norfolk Canyon at a depth of 220-250 fm each caught six baskets (480 pounds) of jumbo fluke in 40 minute tows. Though this amount is not substantial when compared to the catches of trawlers that were working between 50-100 fm, it is suprising because the net ("41") was not a flat net and there were no heavy chains on the foot rope to "tickle" up flounders from the bottom. The unexpected catch of such quantities of large flounder with an inappropriate rig has stimulated speculation that there might possibly be a potential deepwater flounder fishery.

The first phase of the deep water exploratory trawling was terminated on March 7, 1983. It was decided that conducting further operations into the latter parts of March would not provide an accurate assessment of "true" winter conditions but that trawls conducted during this period would be more indicative of spring time conditions.

Summary of Virginia Cavalier Trips 1983-1984

Three seperate trips were conducted for a total of 14 days. Of these 14 days, a total of 9 days were actually spent fishing when the weather moderated enough to permit trawling on either the shelf or on the slope. The duration and dates of each trip are as follows: (Trip #1) Dec. 5, 1983 to Dec 10, 1983, six days, (Trip #2) Dec. 12, 1983 to Dec 16, 1983, five days, (Trip #3) Jan 6, 1984 to Jan 8, 1984, 3 days. Gross catch was approximately 19,781 lbs of finfish and squid with a value of $5,146. A composite picture of the catch reveals that squid (Loligo), fluke, black bass and butterfish were the most abundant of the marketable species caught. Significant amounts of red hake, spotted hake and whiting were caught, but because of their size and shoreside market conditions, they were returned to the sea.

The second phase of the project (Dec, Jan, 1983-84) was characterized by more favorable trawling conditions than the previous year (1982-83), which was due primarily to the earlier starting date. The most obvious change resulted from a moderation in the weather conditions, as opposed to the preceeding year, where the vessel was constantly driven off the grounds by successive storms. There was only one period on the first trip (2 days) when the vessel had to move up on the beach to escape strong Northwest winds. The F/V Virginia Cavalier unlike the F/V Virginia Queen was equipped with a Furuno Weather Fax machine. The addition of this type of weather recorder to the vessels complement of electronics enabled the captain to make long term predictions based upon the supplemental information the unit provided. It was an important piece of equipment for evaluating weather conditions and implementing a successful fishing strategy.

Another apparent benefit from an earlier starting date was the pronounced absence of spiny dogfish. Dogfish migrate annually from their summer grounds on Georges Bank and the Gulf of Maine to their wintering area off the Mid-Atlantic Bight. This migration, which is triggered by changes in water temperature, generally occurs in early to mid December. Unseasonably warm temperatures in the mid-Atlantic region this fall (1983) kept water temperature up to 55°F, which delayed the dogfish presence until early January. Dogfish were virtually absent in all of the deepwater tows and the largest single tow, which happened to be on the shelf, caught less than 1000 lbs. This amount of dogfish would not even be considered to be a nuisance by most fisherman and would be culled out with the remaining trash fish.

The true money species for the period was Loligo squid as evidenced by the 13,000 pounds that was landed during the first two trips. Most of the squid were harvested between the 85 fm contour and the 120 fm contour and were approximately 4-5 fm off the bottom. Because of this condition, the only way to effectively trawl for the squid was with a high-rise net. The Cape May rope net used in the project had a vertical opening of 27', though it can get as high as 32' when the vessel is turning. Midwater gear coupled with the addition of a net sounder which would indicate the position of the net over the bottom would probably be more effective than conventional high-rise nets when the squid are found off of the bottom.

Ninety-seven percent of all the squid harvested during this period had a mantle length of over 4 inches. This was a direct result of not using a small-mesh liner in the cod end. The use of a liner is a standard procedure for vessels engaged in the summer squid fishery (Illex) because it prevents the squid from being squeezed out of the 2" and 2 1/4" cod end meshes. Captain Norris Hogge of the F/V Virginia Cavalier expressed the opinion that a liner should be used because it increases the catch by a one third. There are several apparent drawbacks in using a small-mesh (1/4") liner. Because of its light construction, the liner is continually tearing up, chaffing out, or bursting under heavy loads and has to be replaced frequently. Vessels with only one net reel will find this to be a time consuming maintenance problem that will prevent them from shooting back immediately after hauling. The use of a liner also increases the catch of juvenile squid or "bullets" which, at this time, have little or no marketable value. However, the development of processing and marketing strategies, i.e. canning or freezing, could make the use of small mesh liner a viable economic option.

The most productive tows were taken along the 125 fm edge due east of Wanchese, N.C. and on the 100 fm edges of the Norfolk and Washington Canyons, with the average 2 hour tow catching 1500-2000 lbs of squid. Other vessels in the area fishing for squid reported similar catch rates, among these were the F/V Virginia Reel, F/V Virginia Wave and the F/V Calvin L. Stinson. All of these vessels were concentrating their trawling activities during the first part of December in that area of the slope that lies south of Norfolk Canyon and north of Cape Hatteras.

The true deepwater tows (those in excess of 175 fm) would consistently catch 2000-3000 lbs of "trash fish" (whiting, hake red) per two hour tow with a high-rise net. The abundance of each of these species, which were 6-9" inches in length, was uniform and there was little variation in catch per unit effort in all seven of the designated fishing zones. Because of the relatively small size of the fish, it would appear that there is no present marketing/processing strategy that could make use of these stocks. However, it has been reported that larger fish inhabit that area of the slope deeper than 350 fm.

In the event that there is a marketable product to be fished at these depths, some consideration should be given to the feasibility of developing a class of U.S. catcher/processers that could be directed at this type of resource.

Because of restrictions in the amount of cable that could be placed on the winches, both vessels could not trawl effectively below 250 fm. The Marco WT-101 winches aboard each vessel had a maximum capacity for 500 fms of 3/4" trawl cable and ground wire. Even with a 1 1/2 to 1 ratio of wire to depth, this class of vessel can not effectively trawl at these depths. Towing large amounts of cable necessary to fish 10' to 11' doors restricts the speed of the vessel and uses all of the vessels available horsepower.

All of the exploratory trawls were completed on Jan 8, 1984 and the vessel returned to her traditional winter fishery trawling for scup and black bass. It is apparent that any potential development of the slope fisheries will be determined by supply, demand and ex-vessel prices for squid.

Conclusions and Recommendations

The conclusion section will evaluate two distinctly different approaches for slope trawling: 1) Fishing the slope with the existing vessels in the fleet and a description of the changes necessary to make it profitable to operate on the slope, 2) Fishing the slope with a new class of vessel specifically developed for year round catching and at-sea processing.

Foreign nations (USSR, Poland, Spain, Japan etc.) have been successfully engaged in distant water fishing since the 1950's. This harvesting effort has resulted in the development of a multitude of deepwater fishing technologies. Any domestic deepwater venture will have to integrate these technologies into their fishing plan to assure a successful transition from nearshore to offshore deepwater harvesting or a combination of both. Countries enganged in a distant water fishery have found it necessary to develop a class of vessels that operate away from port for extended periods of time and have adequate freezing and storage capabilities. The Soviet B.M.R.T. class stern trawler is typical of the type of vessel that has been successful harvesting fish stocks in the Northwest Atlantic. These vessels were generally 85 meters in length and were extensively outfitted with state of the art gear and processing equipment. Generally, U.S. vessels lack the modern technological advances, particularly sophisticated freezing units, freezer holds and modern processing equipment which can found on foreign vessels. Historically the U.S. fisheries have been directed at a domestic fresh fish market with vessels making 5 to 10 day trips and storing their catch in an iced hold. Unfortunately, the species that inhabit the outer slope demand better handling procedures than are practiced aboard most U.S. trawlers. Domestic markets for the so called "underutilized species" are just beginning to develop as a result of extensive market development efforts by the Regional Fisheries Development Foundations.

A squid fishery in the months of November and December would appear to be the best opportunity for U.S. vessels hoping to exploit the continental slope. At the present time, it would not be economically feasible for a vessel to engage in a fishery that has such a short season and is virtually unknown. One possible alternative, however, would be boxing limited amounts of squid (5,000-10,000 lbs) for a high quality special domestic market.

In favorable weather, 80-90 vessels could trawl along the 100-150 fm contours of the slope, handle the squid with iced polyethelene stackable boxes and land a high quality product ashore. This concept would only be successful if there was a guaranteed price that would be sufficient to compensate the vessel owner for the inital capital outlay and the crew for the additional effort of boxing at sea. However, under present pricing conditions it would be unrealistic to assume that there could be any mechanism that would be able to effectively guarantee prices before a vessel would depart for the fishing grounds.

The fishing fleet of the mid-Atlantic, as it is structured today, is not suitable for winter slope trawling for three major reasons;

1) The vessels are not large enough (80°-90°) to fish the slope in marginal weather (30 knots and up) and would spend too much time jogging or steaming to the shelf; 2) The months of November and December, when product is available, is not a sufficiently long enough period to warrant the financial committment for conversion to deepwater trawling; 3) The presence of spiny dogfish increases as the winter progress. Initial indications are that any directed fishing effort in this region will have to be conducted in the early winter months and be totally focused upon squid.

Because the existing vessels in both the mid-Atlantic and Northeast are not large enough to be economically viable for deepwater slope trawling, it would appear that the economic climate is ready to support domestically built catcher/processors which could be utilized for both shelf and slope fisheries.

Some considerations for the optimum catcher/processor would include: 1) The vessel would be 160 - 180 ft. class and be documented at less than 200 registered tons to take advantage of the regulations that govern this type of vessel; 2) the vessel would have 1500 h.p. with kort nozzels, variable pitch propellors and a bulbous bow; 3) deck machinery would include: level winding hydraulic winches with a capacity for 750 fm of 1" trawl wire, 2 hydraulic net reels for optimizing hauling and setting times, 2 "Rowe" type hydraulic cargo booms for self loading and unloading capabilities and a hydraulically controlled hatch forward of the stern ramp to clear the product off the deck; 4) refrigeration system capable of processing 50,000 pounds per day in horizontal compression plate freezers and a minimum of 20,000 cubic feet of freezer storage (300 tons); 5) chilled sea water (CSW) tanks with a capacity for 150,000 pounds which would be used when there was a product back up or for shore side processing when the storage hold was full; 6) modifications to enlarge the high rise nets that are presently in use, midwater nets, doors and the accompanying necessary electronics would be needed to complement the vessel's demersal gear and to increase its harvesting capabilities; 7) the vessel would have a processing crew of 18 (approximately) and a fishing crew of six including the captain; and 8) the vessel would have the processing equipment to handle the following species for both domestic and foreign markets; squid, mackerel, butterfish, spiny dogfish and miscellaneous ground fish. The present cost of a vessel of this class is reported to be approximately $7 million and several are reportedly in the planning stages. It is obvious that a vessel of this type would have to land significant quantities of product to be economically feasible. Until a vessel of this type is developed to harvest year round for both shelf and slope species, winter trawling will continue to be a limited and risky venture for conventionally equipped trawlers.

ECONOMIC ANALYSIS

Introduction

The success of any fishing enterprise is determined by it's ability to deliver quality fish products to the dock and maintain a reasonable net profit after tax. Any attempt to move away from established fishing patterns must be evaluated very carefully to insure that the vessel remains profitable. Whether the change in fishing patterns involves fishing for underutilized species or fishing in new areas for traditional species, there is an element of risk that must be overcome if the fisherman is to reap the expected rewards. Any fisherman attempting to exploit the continental slope fishery must accept a high degree of risk.

The continental slope project was initiated to explore the feasibility of conducting fishing operations on the slope during the winter months. The study was designed to operate as closely as possible to a commercial fishing operation. Therefore, the project did not operate under typical scientific constraints (i.e. targeting specific species, equal numbers of tows in each area, etc.). Instead, various trawl areas were identified and the fishing plan attempted to provide an equal number of trawls in each area whenever possible. The vessel was allowed to fish on the shelf during inclement weather and was allowed to move to new grounds if commercial quantities of marketable species were not encountered. Any commercial fishing venture would operate in this manner to optimize the available fishing time, even if it results in a reduced level of effort in the deep water fishery.

There were two primary goals associated with the study. One goal of the study was to evaluate whether commercially valuable species are present on the slope during the winter months. Another goal of the study was to provide estimates of the expected costs and returns a fisherman would experience if he were to implement the fishing plan followed during the study. The results of the study will provide a clear indication of the commercial feasibility of harvesting on the continental slope during the winter months and should provide commercial fishermen with a useful tool to assist them in their decision making process.

Market Analysis

The marketing analysis has been confined to marketable species actually captured and brought to shore in economic quantities. No effort was made to address the marketing problems of various minor species that are not likely to have an appreciable market impact. The following outline (Table 1) describes the species captured, the approximate total catch by species, the price range for each species, and the eventual market destination.

A careful review of the market outline reveals that the majority of the product delivered to the dock was consumed in domestic markets. It is obvious that within each species category strong domestic markets exist outside of the Virginia coastal area for large, high quality finfish. The remainder of the finfish in the small size categories do not command a high market value and are

TABLE 1

MARKET OUTLINE

Species	Catch	Price Range	Catch/Day	Destination
Bluefish	875	.05-25	34 lbs.	Local
Butterfish				
Medium	69	.30	3 lbs.	Local
Small	85	.25	3 lbs.	Local
Fluke				
Jumbo	428	.80-1.40	16 lbs.	Phil, N.C., Fla.
Large	1648	.50-1.25	63 lbs.	Phil, N.C., Fla.
Medium	1457	.40-1.00	56 lbs.	Phil, N.C., Fla.
Small	1259	.20- .65	48 lbs.	Phil, N.C., Fla.
Grey Sole	25	.20	1 lbs.	N.C.
Monkfish				
Large	30	.50	1 lb.	overseas
Small	25	.35	1 lb.	overseas
Porgy				
Large	1703	.35- .50	66 lbs.	Penn.
Medium	3725	.30- .35	143 lbs.	Penn.
Small	5938	.12- .25	228 lbs.	Local
Pin	4400	.02	169 lbs.	Local
Sea Bass				
Jumbo	20	1.50	1 lb.	Illinois
Large	1284	1.00-1.25	49 lbs.	Ill., N.Y., Penn.
Medium	2138	.70- .75	82 lbs.	Ohio, Penn.
Small	3447	.30- .40	132 lbs.	Va.
Mice	580	.15	22 lbs.	Local
Sea Trout				
Large	107	.45	4 lbs.	Norfolk
Medium	72	.25	3 lbs.	Norfolk
Small	286	.15	11 lbs.	Norfolk
Squid	22,319	.20- .40	858 lbs.	U.S. & overseas
Whiting	275	.10- .30	111 lbs.	Local
Total Catch	51,745	Avg Price .3338	2005 lbs/day	

consumed locally to avoid unnecessary handling and transportation costs.

The project did not produce a significant amount of underutilized species; therefore, the harvest was readily absorbed through existing marketing channels. If these species were harvested in large volumes, on a continuous basis, as a result of an expanded fishing effort on the continental slope, existing markets might be deluged with product. This could have a dramatic negative impact on ex-vessel prices. Since the majority of the harvest was composed of traditional mid-Atlantic species, the results of the market analysis does not provide enough information to draw any conclusions about the market's ability to absorb increased volumes of underutilized species on a regular basis.

Budget Analysis

Alternative budgets (Tables 4, 5, 6) for a vessel participating in the nearshore North Carolina-Virginia groundfish fishery as well as a vessel pursuing a fishing plan similar to the one used during the continental slope project will be presented. These budgets are representative of fishing patterns and expected catches during the months of December through February.

The budgets provide cash flow estimates which are used to estimate the pay back period for the investment in gear and equipment necessary to pursue deep water trawling on the slope. The catch, revenue and cost estimates, for the Virginia-North Carolina groundfish fishery were developed from representative samples of vessels of similar size and gear configuration as those used in the project. The estimates projected for the continental slope are the result of an extensive analysis of the data compiled during the study.

Assumptions of the Analysis

1) All estimates are pro-rated over a 3 month period of the year. (December, January, February).

2) The vessel operating in the North Carolina-Virginia nearshore fishery would be expected to catch three primary species. Marketable commercial by-catch is expected to be minimal so it has been ignored in the analysis. The three primary species are projected to be captured and sold in the following quantitites at the following prices:

Species	Quantity/Day	Avg. Price/lb.
Fluke	1500 lbs.	$.75
Scup	600 lbs.	$.30
Sea Bass	300 lbs.	$.60

3) Crew shares were estimated using a 60/40 lay with the crew responsible for ice, fuel, and food. A 5% captain's bonus and a 2% charge for electronics maintenance and repair are considered to be joint expenses of the vessel and crew. These two expenses are charged against the gross catch before the lay is applied. All other expenses are charged to the vessel.

4) Interest expenses are estimated using a 12% annual percentage rate over 10 years. The total interest cost is estimated using an average value of $450,000. This figure is consistent with similar vessels in the fishery. Interest costs are projected against the entire value of the vessel to account for the return the owner could expect from alternative investments (opportunity cost).

5) Ice costs are estimated at 30 tons per trip (trip equals 7 days of fishing) at 30 dollars per ton.

6) Fuel costs are projected using 25 gallons per hour with the vessel harvesting 10 hours per day. Total fuel costs are estimated uisng a price of $1.00 per gallon of fuel consumed. A 16 hour fuel surcharge is added to each trip for the slope fishery to account for the extra running time to and from port.

7) Maintenance and repair costs are estimated at 5 percent of the hull cost. All hull, engine, and fishing gear costs are included in this estimate.

8) Food costs are projected at $7.50 per crew member per fishing day (Crew of 6).

9) It is estimated that there will be 15 available fishing days per month on the continental slope and 18 available days each month in the North Carolina-Virginia groundfish fishery.

10) Supplies are estimated at $100 per month.

11) General and administrative costs are estimated at $200 per month.

12) Insurance is estimated at 2% of the hull cost plus $1000 per man.

13) Depreciation is estimated using a straight line method over 10 years. The increase in depreciation allocated to the continental slope venture results from the extra capital expenditures necessary to participate in the fishery. These charges were spread equally over the 3 month fishing period over the 3 year expected life of the equipment.

14) The analysis assumes that a 50% marginal tax rate applies to all net income after expenses.

TABLE 2

CAPITAL EXPENDITURES NECESSARY
FOR THE CONTINENTAL SLOPE FISHERY

1) Purchase transducer, haul out vessel, and installation of transducer.

A)	Purchase	1100
B)	Haul out ($7.50 per ft.)	616
C)	Installation	200
	Total Installation Cost	1916

2) Purchase 200 fathoms of 3/4", 6x19 thread cable for deep water trawling. ($1.14/ft.) 1368

3) Purchase 10 ft. wooden doors for deep water trawling. 4500

4)	A)	Purchase and Installation - Transducer	1916
	B)	Purchase - Cable	1368
	C)	Purchase - 19 ft Doors	4500
		Total Investment	7784

TABLE 3

REVENUE PROJECTIONS

North Carolina/Virginia Fishery

Species	Daily Catch	Price/lb.	No. of Fishing Days	Revenue
Fluke	1500 lbs.	$.75	54	$60,750
Scup	600 lbs.	$.30	54	$ 9,720
Black Sea Bass	300 lbs.	$.60	54	$ 9,720
			Total Revenue	$80,190

Continental Slope Fishery

Species	Avg. Daily Catch	Avg. Price/lb	No. of Fishing Days	Revenue
Mixed	2005 lb.	$.3338	45	$30,117
			Total Revenue	$30,117
Mixed	2005 lb.	$.75	45	$67,669
			Total Revenue	$67,669

TABLE 4

CONTINENTAL SLOPE FISHERY
($.3338/lb.)

Gross Revenue			$30,117
Joint Costs			
Electronics Maintenance			602
Captain's Bonus			1505
		Total Joint Costs	$2107
Crew Share			$16,806
(less) Crew Costs			
Fuel	13,822		
Ice	5,780		
Food	2,025	Total Crew Costs	$21,627
		Net Crew Share	$(4822)
		Net Share Per Crew Member	(803)
Vessel Share			$11,204
(less) Vessel Costs			
Principal and Interest	6,457		
Insurance	3,750		
General and Admin. Costs	600		
Depreciation	12,115		
Maintenance and Repair	5,625		
Supplies	300	Total Vessel Costs	$28,847
		Net Income Before Tax	($17,643)
		Income Tax	0
		Net Income After Tax	($17,643)
		Depreciation	$12,115
		Net Cash Flow After Tax	($ 5,528)

TABLE 5

CONTINENTAL SLOPE FISHERY
($.75/lb.)

Gross Revenue			$67,668
Joint Costs			
Electronics Maintenance			1353
Captain's Bonus			3383
		Total Joint Costs	$4736
Crew Share			$37,759
(less) Crew Costs			
Fuel	13,822		
Ice	5,780		
Food	2,025	Total Crew Costs	$21,627
		Net Crew Share	$16,132
		Net Share Per Crew Member	$ 2,689
Vessel Share			$25,173
(less) Vessel Costs			
Principal and Interest	6,457		
Insurance	3,750		
General and Admin. Costs	600		
Depreciation	12,115		
Maintenance and Repair	5,625		
Supplies	300	Total Vessel Costs	$28,847
		Net Income Before Tax	($3,674)
		Income Tax	0
		Net Income After Tax	($3,674)
		Depreciation	$12,115
		Net Cash Flow After Tax	$8,441

TABLE 6

VIRGINIA-NORTH CAROLINA GROUNDFISH FISHERY

Gross Revenue			$80,190
Joint Costs			
Electronics Maintenance			1604
Captain's Bonus			4010
		Total Joint Costs	5614
Crew Share			$44,746
(less) Crew Costs			
Fuel	13,500		
Ice	6,943		
Food	2,430	Total Crew Costs	$22,873
		Net Crew Share	$21,873
		Net Share Per Crew Member	$3645
Vessel Share			$35,444
(less) Vessel Costs			
Principal and Interest	6,457		
Insurance	3,750		
General and Admin. Costs	600		
Depreciation	11,250		
Maintenance and Repair	5,625		
Supplies	300	Total Vessel Costs	$27,982
		Net Income Before Tax	$7,462
		Income Tax	$3,731
		Net Income After Tax	$3,731
		Depreciation	$11,250
		Net Cash Flow After Tax	$14,981

Partial Budgeting Analysis

The partial budgeting technique is an extremely useful technique for evaluating small changes in a fisherman's operation. Partial budgets can be used to estimate the net economic effect of minor adjustments in fishing patterns or changes in gear and equipment. Only those costs and returns that change are used in a partial budget; costs and returns that do not change are not included.

Partial budgeting is based on the principle that a small change in a business will result in one or more of the following effects:

1) Cause additional revenues to be received.

2) Eliminate or reduce some costs.

3) Cause additional costs to be incurred.

4) Eliminate or reduce some returns.

The first two effects (additional returns and reduced costs) result in positive economic effects. The third and fourth effects (reduced returns and additional costs) result in negative economic effects. The net effect will be the sum of the positive economic effects minus the sum of the negative economic effects. A positive net effect indicates a positive economic return resulting from the change; a negative net effect indicates the opposite.

The partial budgeting analysis (Table 7) contained in this report will analyze the net economic effect of shifting from the North Carolina-Virgina groundfish fishery to the continental slope fishery. The assumptions used in the partial budgeting analysis will be exactly

TABLE 7

PARTIAL BUDGETING ANALYSIS

Current Plan: Direct trawling effort at the groundfish stocks on the continental shelf off of North Carolina and Virginia.

Change: Direct trawling effort at dominant commercial and under-utilized species on the continental slope off of New Jersey to North Carolina.

Positive Economic Effects		**Negative Economic Effects**	
Additional Returns		**Reduced Returns**	
Gross Revenue	$30,117	Gross Revenue	$80,190
Reduced Costs		**Additional Costs**	
Crew Share	$44,746	Crew Share	$16,806
Electronics Maintenance	$ 1,604	Electronics Maintenance	$ 602
Captains Bonus	$ 4,010	Captains Bonus	$ 1,505
A. Total Annual Additional Returns and Reduced Costs (3 Months)	$80,477	B. Total Annual Additional Costs and Reduced Returns (3 Months)	$99,103
Net Change In Income To The Vessel (A-B)	($18,626)		

the same as those used in the detailed budgets developed earlier in the report.

The partial budgeting analysis indicates that the move from the existing groundfish fishery to the continental slope fishery results in a net economic loss to the vessel $18,626 during the winter fishing season. The loss of expected revenues from the North Carolina-Virginia fishery is the primary reason behind the expected net loss incurred by a vessel shifting to the continental slope fishery. The reduction in other operating costs is not sufficient to overcome the significant loss in expected revenue.

Payback Analysis

There are many financial analysis techniques available to assess investment or management alternatives in the commercial fishing industry. One technique, which is very easy to use and offers a great deal of insight to the commercial fisherman, is the payback period analysis. This technique has been used for years by the U.S. business community, and if used with caution, can be extremely useful as a decision making tool.

The payback period is calculated by dividing the initial investment required to implement a project by the expected net annual cash flows after tax. This calculation provides an estimate of the period of time necessary to "payback" the initial investment associated with implementing a project. Because the payback period only focuses on the cash flows required to "payback" the initial investment, it ignores all cash flows which accrue after the initial payback period.

Projects often require a long lead time to mature. In this case, it is not unusual for the project to realize it's greatest cash flows after the initial payback period. If a slow maturing project is compared to one which has substantial cash flows early in it's life, the slow maturing project may not fare well if the payback analysis is used as the only investment criteria. Therefore, one must carefully examine cash flows before and after the payback period to insure that the best project is chosen.

A payback analysis focusing on a directed harvesting effort on the continental slope under existing market conditions (33.38 cents per pound) was not feasible. This was due to the fact that the budgets projected for the continental slope fishery indicated that the vessel would generate negative cash flows after tax. The payback calculation requires positive cash flows to provide meaningful results. Negative cash flows imply that the vessel will not generate enough cash to "payback" the investment in gear and equipment necessary to exploit the slope.

Because the project was implemented to assess the future as well as the current fishing potential of the slope, the payback technique was used to explore the feasibility of harvesting under improved market conditions (Average price of 75 cents per pound). This analysis was deemed to be of value because the general expectation is that future fishing effort wil be directed further offshore if and when existing fish stocks are depleted or if expanding demand for fish protein results in improved market conditions for underutilized species.

The payback analysis provides an opportunity to develop a value for the "threshold price" which will be necessary to encourage fishermen to enter the continental slope fishery. The market price employed in the analysis can be used by commercial fishermen as a key indicator of the economic feasibility of fishing on the continental slope.

The key elements in the payback analysis are outlined below:

A) Capital expenditures for continental slope fishing - $\underline{\$7784}$

B) Annual cash flow (3 month period) with average market price of 75 cents per pound - $\underline{\$8441}$

C) Cash Flow per Fishing Day (CFFD) = Annual Cash Flow From the continental slope ÷ number of available fishing days on the continental slope; CFFD = $\frac{\$8441}{45} = \$187.57$

D) Payback Period $= \frac{\text{Capital Investment}}{\text{CFFD}}$

$$= \frac{\$7784}{\$87.57}$$

$$= 41.5 \text{ fishing days}$$

The payback analysis reveals that an across the board improvement in price (75 cents per lb.) is necessary to make continental slope fishing economically feasible. The analysis indicates that an increase in the average market price to 75 cents per pound would result in a payback period of approximately 42 fishing days.

Therefore, one can logically expect that it would take a fisherman one three month season to recoup his initial investment in gear and equipment under these improved market conditions.

Conclusions of the Economic Analysis

The economic analysis provided in this report presents three major impediments to commercial exploitation of the continental slope. First, existing market prices of the target species are inadequate to stimulate commercial development. Second, vessels operating in the mid-Atlantic are not capable of providing the onboard handling necessary to maintain product quality and maximize ex-vessel price. Finally, vessels operating in the mid-Atlantic are incapable of operating for extended periods of time under the weather conditions prevalent during the winter months.

At the present time, market prices are insufficient to sustain a viable commercial fishery on the continental slope. Therefore, it is impractical for a fisherman to leave existing groundfish fisheries in the mid-Atlantic to harvest on the slope. Any large scale effort to exploit the slope will be dictated by the market conditions for the target species (i.e. squid, whiting, etc.). It is projected that a price increase of approximately 125% is necessary to make this fishery competitive with existing fisheries in the region.

The target species in the project (squid, whiting, etc.) present special handling problems which must be addressed before fishermen will receive the maximum ex-vessel price for their products. Squid are extremely fragile creatures which do not respond well to conventional onboard handling techniques. Squid should be sorted, frozen, and boxed at sea if it is to remain price competitive with squid harvested in other parts of the world. Substantial quantities of whiting were captured on the slope. These fish were not delivered shoreside because it was determined that they would have no commercial value after sitting in the fish hold for several days. Because these fish are so susceptible to mishandling they must be processed and frozen into fillet blocks to achieve their maximum market value.

Even though it was not a target species, dogfish were harvested in substantial quantities. As a matter of fact, dogfish were so abundant that the vessel was forced to curtail fishing activities on more than one occasion to avoid fouling the net. It has long been recognized that dogfish exist in commercial quantitities in the mid Atlantic. Consumer studies have indicated a strong preference for dogfish fillets. The major problems encountered in the fishery revolve around the implementation of sound onboard handling techniques and the disposal of the processing wastes resulting from shoreside processing activites. At-sea processing could provide some reasonable alternatives for resolving these problems.

The continental slope fishery presents some difficult logistical problems for fishing vessels. To reach the slope from existing fishing grounds requires a considerable amount of nonproductive running time. This results in additional fuel costs. The weather conditions experienced on the slope are more severe than those found on the shelf. This can result in a reduced number of available fishing days as well as a reduced harvest. Because of these logistical problems it is apparent that existing vessels are not well suited for exploiting the slope. Somewhat larger vessels, capable of operating in inclement weather conditions for extended periods of time will be the norm rather than the exception in this area.

The mid-Atlantic fishing fleet, in it's current form, is incapable of substantially increasing the daily harvest or producing the high quality, value-added products which will be necessary to stimulate demand and increase ex-vessel prices. The impediments to development of this fishery point to one conclusion: A multipurpose catcher/processor in the 150-180 foot range must be employed in this fishery if it is to realize it's full economic potential.

A catcher/processor should be capable of operating on the slope for a minimum of 15 days. It should have the equipment necessary to sort, box, and freeze squid. It would be advantageous to have filleting machines on board to take advantage of the whiting and dogfish stocks if and when they develop into accepted commercial species. The vessel must be equipped with state of the art electronics and midwater trawls to take advantage of the various species found on the slope.

Even if catcher/procesors were available for use on the slope today, the products produced on board would face considerable difficulty in penetrating existing foreign and domestic markets. Market development efforts have been under way for some time with some significant successes. These efforts must be continued and expanded if the continental slope fishery is to present a viable option for fishermen in the mid-Atlantic.

In closing, the economic analysis gives a clear indication that the continental slope fishery does not represent a viable option for mid-Atlantic fishermen at the present time. If the development opportunities on the slope are to be realized new equipment and harvesting strategies focusing on extended trips and on-board, value-added processing must be employed. In addition, market development activities must be directed at the most promising target species to try to stimulate market demand. A fully integrated program focusing on these objectives must be implemented if this fishery is to provide any significant new opportunities for mid-Atlantic fishermen.

ANALYSIS OF FOREIGN FISHING EFFORT

Introduction

Distant water fishing fleets have operated in U.S. waters since the early 1950's. These fleets have been characterized by large (200-350 feet in length) catcher/processors capable of harvesting, processing, and freezing large volumes of finfish and shellfish at sea. The size and design of these vessels has enabled them to operate away from port for extended periods of time and under weather conditions which would seriously limit the effectiveness of the majority of the fishing vessels in the U.S. fishing fleet. The ability to operate away from port for extended periods of time coupled with the ability to produce a quality, consumer ready product has permitted these foreign vessels to exploit several species which, until recently, had generated little or no domestic commercial activity.

The U.S. fishing fleet has grown dramatically since the declaration of the 200 mile limit in 1976. This expansion, and the increase in fishing effort which accompanied it, has resulted in the decline of several commercially important species. Many U.S. fishermen, unable to meet their fixed and variable costs of operation, have been forced to consider shifting from more traditional fisheries to several underutilized species. This move, from traditional fisheries into the underutilized species, will require that U.S. fishermen modify their traditional fishing techniques and patterns to implement procedures which are more compatible with the high volume catches and low ex-vessel prices characteristic of underutilized species.

The joint venture mechanism, put in place by the Regional Fisheries Management Councils, has been effective in helping to familiarize U.S. fishermen with new types of gear, electronics, and fishing techniques. The next step will be the largest of all. Many underutilized species are highly mobile. In addition, several require special onboard handling practices or their ex-vessel values are so low that they do not warrant bringing them ashore. All of these factors point towards the gradual evolution of the U.S. fishing industry from a small vessel harvesting strategy towards vessels which can harvest and process fish at sea. The ability to conduct vertically integrated fishing activities at sea would permit U.S. fishing vessels to retain more of the value added portion of the final price paid by consumers. This would enable U.S. fishermen to achieve the economies of scale that are necessary to exploit the remaining underutilized species in the mid-Atlantic.

Any decision to radically change fishing patterns and effort should be based on fact. In this case, the industry must assess the available supply of fish. Since the enactment of the Magnuson Fisheries Conservation and Management Act of 1976 (FCMA), the United States has implemented a fisheries observer program. This program enables NMFS to place observers on board foreign fishing vessels to gather important harvest data. The observer program has given NMFS the opportunity to gather quality data on both foreign fishing effort and harvest within the 200 limit.

Foreign Fishing Effort and Harvest in the U.S. FCZ

Figure 1 provides a list of the top five fishing nations operating in the North Atlantic region of the U.S. Fisheries Conservation Zone. In the period between 1979 and 1982 Canada harvested more product from U.S. North Atlantic waters than any other nation. The primary species harvested by the Canadians ranged from scallops to haddock and finally to cod. Canadian production peaked in 1981 with a total North Atlantic harvest of 29,911 metric tons.

Spain was the second largest producer in the U.S. North Atlantic between 1979 and 1982. The primary species harvested in this area, during this period of time, was squid. Both Illex and Loligo species were harvested. Peak production for Spain occurred during 1981 with a total harvest of 19,725 metric tons.

Japan and Mexico were major fishing nations during the period of interest, but their harvest has declined significantly over the years. As a matter of fact, Mexico no longer fishes in the North Atlantic after taking a peak catch of 8,085 metric tons in 1979. Japan's production grew steadily until 1981 when it reached it's zenith at 10,960 metric tons. Both Japan and Mexico concentrated the majority of their fishing effort on the two squid species, Loligo and Illex.

One of the more interesting trends highlighted in Table 7 is the emergence of Italy as a major fishing nation. Italy ranked fifth in total North Atlantic production during 1979 with a harvest of 6,690 metric tons. Italy's production has improved consistently over the

Figure 1 - Top Five Foreign Fishing Nations in the North Atlantic Region of the F.C.Z.

(1979 - 1982)

	1979			1980			1981			1982		
Ranking	Country	Primary Species	Metric Tons	Country	Primary Species	Metric Tons	Country	Primary Species	Metric Tons	Country	Primary Species	Metric Tons
1	Canada	Scallops	25,414	Canada	Haddock	28,479	Canada	Cod	29,911	Canada	Cod	26,983
2	Spain	Illex	11,541	Spain	Illex	17,521	Spain	Loligo	19,725	Spain	Loligo	15,556
3	Mexico	Loligo	8,085	Japan	Loligo	10,765	Italy	Loligo	12,399	Italy	Illex	14,746
4	Japan	Illex	7,712	Italy	Illex	9,445	Japan	Loligo	10,960	Japan	Loligo	7,146
5	Italy	Illex	6,690	Mexico	Illex	1,510	-	-	-	-	-	-

*Information presented in this table was taken from Fisheries of the United States 1979, 1980, 1981 and 1982, U.S. Department of Commerce, National Marine Fisheries Service.

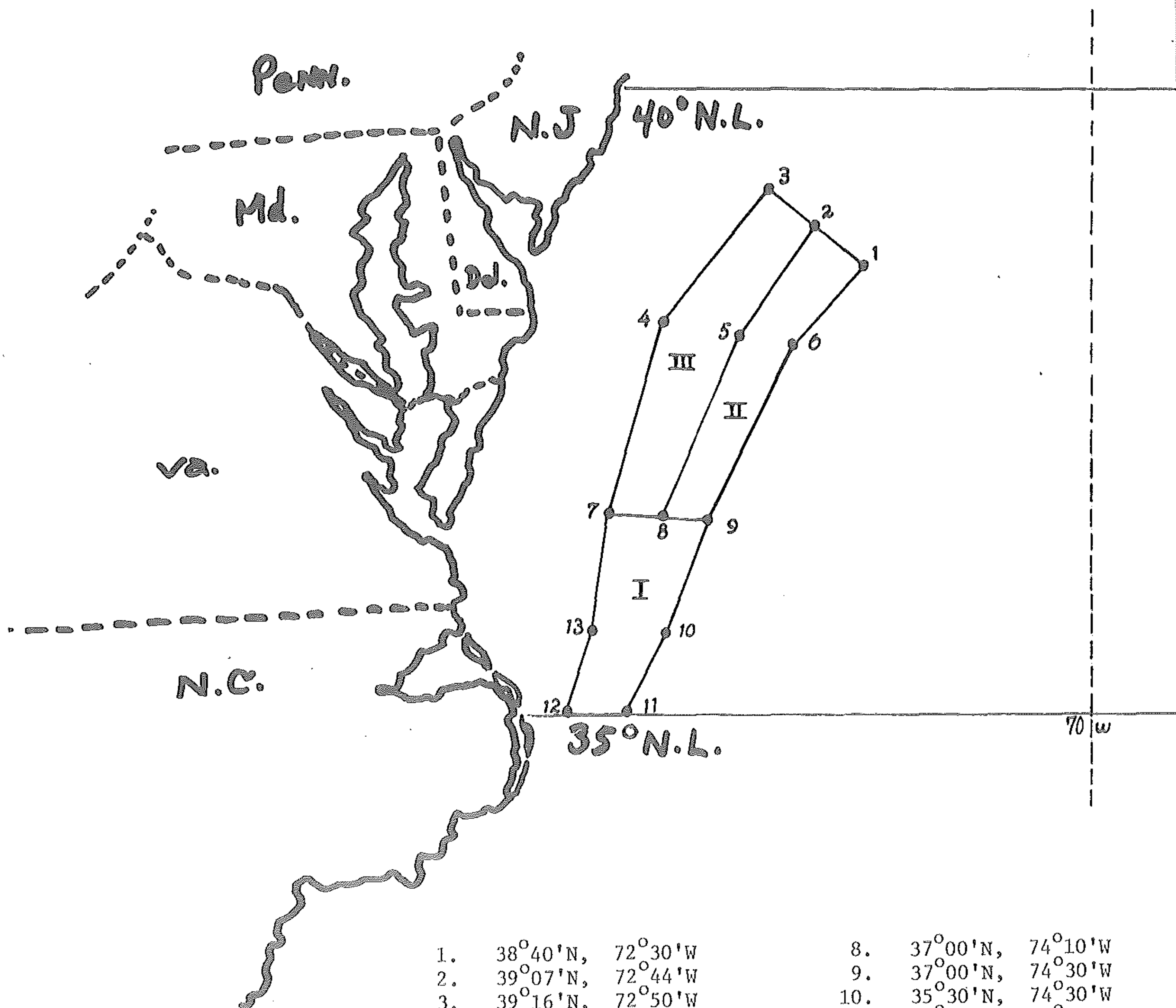
years and peaked at 14,746 metric tons in 1982. This figure placed the Italians just behind the Spanish as the third largest foreign fishing nation in the U.S. North Atlantic.

In addition to compiling statistics on total production by nation and region, the National Marine Fisheries Service keeps more specific data for smaller areas along the U.S. East coast.(1) These areas are designated as Foreign Fishing Windows (Figure 2). There are 5 windows which run parallel to the U.S. East coast. The three of primary interest to mid-Atlantic fishermen are Windows 1, 2, and 3.

Tables 1, 3, and 5 provide a clear indication of the primary target species of the foreign fishing fleet, their relative abundance by fishing area (window), the total fishing effort expended by month in each window, and the average catch by species and month over the six year period between 1978 and 1983. Tables 2, 4, and 6 delineate the average catch per unit of effort (in vessel days) by month and species over the same six year period. The catch per unit of effort analysis must be viewed with some caution because foreign fishing effort in U.S. waters consists of vessels of various sizes and gear types. Therefore, it is difficult to assess the magnitude of effort expended in the various fisheries. Nevertheless, it is safe to say that the foreign vessels operating in the FCZ are, on average, larger and capable of using a greater variety of fishing gear than the

(1) Catch and effort statistics used in this analysis were provided by the National Marine Fisheries Service in Gloucester, Massachusetts.

Figure 2 - Foreign Fishing Windows in the Mid-Atlantic



1.	38°40'N,	72°30'W
2.	39°07'N,	72°44'W
3.	39°16'N,	72°50'W
4.	38°00'N,	74°10'W
5.	38°00'N,	73°53'W
6.	38°00'N,	73°20'W
7.	37°00'N,	74°40'W
8.	37°00'N,	74°10'W
9.	37°00'N,	74°30'W
10.	35°30'N,	74°30'W
11.	35°13'N,	74°50'W
12.	35°13'N,	75°06'W
13.	35°30'N,	74°55'W

current U.S. fleet. For this reason, it is impossible to judge how effective U.S. fishermen would be in pursuing many of the underutilized species using conventional gear and vessels. The prudent fishermen will use the estimates provided in this report as benchmarks only, not as an absolute standard of expected catches in these new fishing areas.

Tables 1 and 2 describe foreign fishing activity in Window 1. The tables reveal that foreign fishing effort in this zone was concentrated in the months of November and December. Foreign fishing activity halted completely after December, presumably due to the migratory nature of the various target species. November is the dominant month for foreign fishing activity in Window 1 with an average of 173 days spent in this area versus 93 in December.

Loligo and Illex squid were the primary species captured in Window 1, both in absolute terms and in the average catch per vessel day. Loligo harvest was greatest in the month of November. Illex catch was relatively stable over the two month period although production was slightly higher in December.

Loligo catch per vessel day was greatest in November while Illex catch was greatest in December. Loligo production per vessel day was slightly higher over the two month period than that of Illex. (4,675 pounds to 3,844 pounds).

The dominant finfish species, both in terms of total production and catch per unit of effort, was silver hake. Silver hake catch was

Table 1

Average Catch Per Month

Window 1 (1978-1983)

(Pounds)

	Mackerel	Butterfish	Illex	Loligo	Red Hake	Silver Hake	Average Days Fished
Nov.	294	52,562	461,690	997,751	2,167	115,170	173
Dec.	514	7,457	560,841	245,786	1,947	93,641	93
Jan.	.0	.0	.0	.0	.0	.0	0
Feb.	.0	.0	.0	.0	.0	.0	0
Total Average Catch (Winter Season)	808	60,019	1,022,531	1,243,537	4,114	208,811	266

Table 2

Average Catch Per Vessel Day

Window 1 (1978-1983)

(Pounds/Day)

Species	Mackerel	Butterfish	Illex	Loligo	Red Hake	Silver Hake	All Species
Month							
Nov.	2	304	2,669	5,767	13	666	9,421
Dec.	6	80	6,031	2,643	21	1,007	9,788
Jan.	0	0	0	0	0	0	0
Feb.	0	0	0	0	0	0	0
Average Catch Per Day (Winter Season)	3	226	3,844	4,675	16	785	9,549

Table 3

Average Catch Per Month

Window 2 (1978-1983)

(Pounds)

	Mackerel	Butterfish	Illex	Loligo	Red Hake	Silver Hake	Average Days Fished
Nov.	8,375	12,791	1,693,414	64,020	4,193	33,780	125
Dec.	12,085	5,411	413,397	272,778	5,033	43,970	102
Jan.	6,393	8,254	180,559	978,216	2,645	43,088	112
Feb.	111,890	128,972	306,356	1,121,792	4,335	47,643	202
Total Average Catch (Winter Season)	138,743	55,427	2,593,726	2,436,806	16,206	168,481	541

Table 4

Average Catch Per Vessel Day

Window 2 (1978-1983)

(Pounds/Day)

Species / Month	Mackerel	Butterfish	Illex	Loligo	Red Hake	Silver Hake	All Species
Nov.	67	102	13,547	512	34	270	14,532
Dec.	119	53	4,053	2,674	50	431	7,380
Jan.	57	74	1,612	8,734	24	385	10,886
Feb.	554	145	1,517	5,553	22	236	8,027
Average Catch Per Day (Winter Season)	256	103	4,794	4,504	30	311	9,998

Table 5

Average Catch Per Month

Window 3 (1978-1983)

(Pounds)

	Mackerel	Butterfish	Illex	Loligo	Red Hake	Silver Hake	Average Days Fished
Nov.	10,322	90,136	1,946,043	1,541,250	32,913	389,858	293
Dec.	37,482	119,104	713,549	3,654,765	71,053	456,088	595
Jan.	4,077	37,402	391,342	1,778,161	13,187	148,381	319
Feb.	18,844	42,441	335,008	2,120,601	9,477	119,383	313
Total Average Catch (Winter Season)	70,725	289,083	3,385,942	9,094,777	126,630	1,113,710	1520

Table 6

Average Catch Per Vessel Day

Window 3 (1978-1983)

(Pounds/Day)

Species / Month	Mackerel	Butterfish	Illex	Loligo	Red Hake	Silver Hake	All Species
Nov.	35	308	6,642	5,260	112	1,331	13,688
Dec.	63	200	1,199	6,143	119	767	8,491
Jan.	13	117	1,227	5,574	41	465	7,437
Feb.	60	136	1,070	6,775	30	381	8,452
Average Catch Per Day (Winter Season)	47	190	2,228	5,983	83	733	9,264

approximately four times as large as the next most abundant species, butterfish (208,811 pounds versus 60,019 pounds). Silver hake production was greatest in November, although the maximum catch per vessel day occured in December.

Average total catch per vessel day for all species was relatively stable over the two month period, although it was somewhat higher in December. The average catch for all species over the entire winter season was slight lower than the peak catch in December.

Window 2 effort was relatively consistent throughout the months of November, December, and January. The month of February, on the other hand, accounts for approximately 38% of the total effort expended over the entire 4 month period. The total amount of effort expended during the November-February period in Window 2 was approximately two times the effort expended in Window 1, although the number of days fished were accumulation over a four month period rather than two months, as was the case in Window 1.

The two dominant species harvested in Window 2 were Illex and Loligo squid. Illex squid was more abundant in November and December while Loligo was captured more frequently in January and February. Illex catch ranged from a high of 13,547 pounds per vessel day in November to a low of 1,517 pounds per vessel day in February. Loligo catches started slowly, averaging 512 pounds per day in November, peaked in January with an average catch per vessel day of 8,734 pounds, and falling off to a value of 5,553 pounds per day in

December. Illex catch average approximately 300 pounds more per vessel day than did loligo over the course of the winter season.

Silver hake was the dominant finfish species captured in Window 2 with an average harvest of 168,481 pounds during the winter season. Mackerel was second in total average catch with a value of 138,743 pounds. The majority of the mackerel was captured during February with fluctuating catches throughout the remainder of the season. Silver hake catch was relatively stable over the winter season with average catches ranging from a low of 33,780 pounds in November to a high of 47,643 pounds in February.

The average catch per vessel day for all species in Window 2 during the winter season was 9,998 pounds. This figure was slightly higher than the comparable figure for Window 1 (9,549 pounds). The monthly averages in Window 2 ranged from a low in December of 7,380 pounds to a high of 14,532 pounds in November.

The average level of fishing effort exerted in Window 3 during the winter season was approximately 3 times greater than the next closest fishing area, Window 2 (1520 days to 541 days). The effort was distributed evenly over the 4 month period except for the month of December. December averaged 595 days of effort over the 6 year period. The next most active month was January, which averaged 319 days of effort. The month with the lowest average fishing effort, November (293 days) had approximately 91 more days of activity than did any month in either Window 1 or 2. This indicates that Window 3 was the favorite fishing area for foreign vessels during the 1978-1983 period.

Loligo and Illex squid were the primary species captured in Window 3 during the years of study. Total seasonal Loligo catches, on average, were aproximately 2.5 times as great as the Illex harvest (9.1 million pounds to 3.4 million pounds). Loligo catch per vessel day was relatively constant during the winter season ranging from a low of 5,260 pounds in November to a high of 6,775 pounds in February. Illex production on the other hand, was concentrated in November (6,642 pounds per vessel day). The Illex harvest declined gradually over the winter season to a level of 1,070 pounds per vessel day in February. The average daily Loligo catch for he winter season in Window 3 exceeded Loligo catch in both Windows 1 and 2.

The primary finfish species harvested in Window 3 was the silver hake. Total silver hake production was greatest in December, although catch per vessel day was highest in November. The average seasonal silver hake harvest was 3 times greater than the next most abundant species, butterfish, (1,113,710 pounds to 289,083 pounds). Peak butterfish harvest occurred in December although the highest catch per vessel day was found in November (308 pounds per day).

The average catch per vessel day for all species in Window 3 ranged from a high of 13,688 pounds in November to a low of 7,437 pounds in January. The average daily production for the winter season was approximately 9,264 pounds. This figure was slightly lower than the comparable Window 1 and Window 2 values (9,549 and 9,998 pounds respectively).

Projected Value of Annual Foreign Fishing Harvest

Once it has been determined that fish are available in relatively consistent supply, the next step in any effort to pursue commercial devlopment of underutilized species requires that an estimate of the relative value of the available fishery resoruces be prepared.

In the economic anlaysis prepared earlier in this report, the weighted average value of the species taken during the continental slope project was estimated to be 33.38 cents per pound. Table 7 provides a projected annual value for the harvest from each of the three foreign fishing windows in the mid-Atlantic using this weighted average value as well as a projected value if the average ex-vessel price improved to 75 cents per pound.

The table shows that at the present time the total annual projected value of the harvest taken by foreign vessels in the mid-Atlantic is $7,353,691. Window 3 is the area where the foreign vessels have consistently taken the most fish; therefore, the projected ex-vessel value is highest in this window. Table 7 also shows that an across the board increase in ex-vessel price to 75 cents per pound would raise the total expected value of the foreign harvest in the mid-Atlantic to almost approximately 16.5 million dollars per year. The magnitude of these numbers is significant because as joint venture arrangements begin to mature, U.S. fishermen can expect to

Table 7

Projected Value of Winter Season

Harvest

Window	Average Catch Per Vessel Day	Price Per Pound	Average No. of Vessel Days (Annual)	Annual Value
I	9,549	$.3338*	266	$ 847,863
II	9,998	$.3338	541	$1,805,497
III	9,264	$.3338	1520	$4,700,331
			Total Expected Value	$7,353,691

Window	Average Catch Per Vessel Day	Price Per Pound	Average No. of Vessel Days (Annual)	Annual Value
I	9,549	$.75**	266	$1,905,026
II	9,998	$.75	541	$4,056,689
III	9,264	$.75	1520	$10,560,960
			Total Expected Value	$16,522,675

*Current weighted average price per pound for species harvested during the continental slope project.

**Projected future price for continental slope species used in the economic analysis.

receive higher prices for their over the side sales. In addition, as foreign fishing effort is reduced in U.S. waters it should permit U.S. companies to be more competitive in foreign markets. If U.S. companies could receive more of the value-added portion of the products being sold overseas it would significantly increase the net value of the underutilized resources which inhabit the mid-Atlantic region.

The estimates presented in Table 7 reflect the tremendous economic potential of the fisheries resources taken each year in the mid-Atlantic. As the U.S. industry grows and matures it will be able to harvest more and more of the species prevalent in the region. Foreign fleets have taken advantage of these resources for years, but they have learned their lessons well. They have caught and processed products at sea so that they can achieve the economics of scale necessary to harvest underutilized species. American fishermen must begin to think in these terms if they are to receive the maximum value for the unexploited fish stocks in the region.

Conclusions

There are many lessons which can be learned from a careful examination of foreign fishing activity in the mid-Atlantic. First one can readily see that several species have been harvested in large quantities over a number of years. The level of effort expended, coupled with the large catches taken, indicate that at least two species, Illex and Loligo squid, appear to be capable of sustaining a viable U.S. fishery.

In this regard, we must assume that foreign markets would be made available to U.S. products if U.S. fishermen adapt quality control techniques similar to those used on board foreign vessels and foreign fishing is gradually phased out. If foreign markets accept a high quality U.S. product it appears that there is a squid resource in the mid-Atlantic capable of sustaining a viable commercial fishery.

Another factor which must be considered in the development of the underutilized resources of the mid-Atlantic is the latest value of the total fishery resource. The magnitude of the annual harvest dictates that even a relatively low ex-vesel price of 33.38 cents per pound results in a total ex-vessel value of over $7,000,000 during the winter season alone. If vessels could be equipped to handle onboard processing this value should be increased significantly.

In an operational sense one can form some conclusions about the fishing strategies pursued by foreign fleets in the mid-Atlantic. First and foremost, foreign activity was overwhelmingly concentrated in Window 3. This resulted in larger total catches although catch per vessel day was slightly lower than was the case in Windows 1 and 2. If Loligo squid were chosen as the target species one could expect to consistently catch an average of approximately 5,000 to 7,000 pounds per vessel day of this species in Window 3. If the fishing plan was designed to maximize total catch per month, the fisherman could concentrate fishing effort in Window 2 during November (14,532 pounds per vessel day), move into Window 1 during December, shift into Window 2 during January and finally move back into Window 3 during February.

After a few seasons the fisherman could establish whether this movement in advantageous. It may be possible to concentrate on Window 3 to maximize harvest to avoid moving from area to area.

If the fisherman wanted to concentrate on Illex squid he would probably concentrate his effort in Window 2 during November, shift into Window 1 during December, then back into Window 2 for the remainder of the winter. In many cases the difference between the expected catch rates are so small that the fisherman would have to factor the increase in running time, fuel costs, etc. into his decision to make a determination of the optimal fishing area.

It is difficult to envision any concentrated effort to target finfish in any of the foreign windows during the winter season. It may be possible to supplement squid harvests with some reasonable level of by-catch. The finfish species that would fit best into this type of fishing plant appears to be butterfish. Butterfish command a relatively high price and require very little onboard handling. If a fishing vessel was equipped to sort, box, and freeze squid at sea, it would be relatively easy to handle butterfish as a supplementary product. Silver hake and mackerel appear to be available in harvestable quantities during various periods throughout the winter but onboard processing requirements would be much more capital and labor intensive.

In closing, the U.S. FCZ continues to hold great promise. There are many species available in this area which have been harvested by foreign nations in large quantities for over 20 years. Many of these species command strong overseas markets and show some potential in domestic markets. Even with all of these positives the U.S. industry must adapt to changing times. Fishermen and processors cannot produce products of varying quality and expect to make headway in existing world markets. They must provide products which meet existing market criteria and they must do it in an economically sound manner. To accomplish these goals it may require a significant change in harvesting and processing strategies. If the resource dictates such a move the industry must be ready to evolve if these new opportunities are to come to fruition.

DESCRIPTION OF CATCHES

Seventy-one tows were performed during project cruises (Table 1, Fig. 1). Of these, twenty-one were done at least partially in depths between 100 and 200 fathoms (Table 2). Fifty-five of the tows, including eight deep (>100 fathoms) tows, were done from the trawler Virginia Queen during three trips in the months of January-March 1983, and sixteen tows, including thirteen deep tows, were done from the trawler Virginia Cavalier on two trips during December 1983. The catch composition of each tow was estimated volumetrically on deck utilizing 2 bushel fish baskets as measuring devices, and subsamples were taken from each deep tow for length frequency measurements. Catches have been converted to pounds using a factor of 60 lbs./bu. for finfishes and 80 lbs./bu. for squid. The "marketable" portion of each catch has been estimated by summing the catches of those species which were actually landing during project activities: bluefish (*Pomatomus saltatrix*), butterfish (*Peprilus triacanthus*), fluke (*Paralichthys dentatus*), grey sole (*Glyptocephalus cynoglossus*), monkfish (*Lophius americanus*), porgies (*Stenotomus chrysops*), black seabass (*Centropristis striata*), grey seatrout (*Cynoscion regalis*), longfin and shortfin squid (*Loligo pealeii* and *Illex illecebrosus*) and whiting (*Merluccius bilinearis*). All fish included in the estimates of marketable catch were not necessarily landed due to being either undersized, in poor condition or comprising too small a portion of a catch to warrant picking out.

Six of the tows were unsuccessful; four of them (including two deep tows) were so filled with spiny dogfish that they had too be tripped overboard, while two tows sustained enough damage on the bottom to release the catches. All of the dogfish fillups occurred during the Virginia Queen cruises in Jan.-Mar., and large catches of dogfish were a persistent problem at the deep stations during these cruises. During the December cruises very few dogfish were encountered at the deep stations, with the result that a much higher proportion of deep tows were performed during the December work with much more satisfactory results.

Table 3 gives a breakdown of catch rates for various segments of the cruises. The deep tows showed a higher overall marketable catch rate (550 lbs./hr. tow time) than those done in less than 100 fathoms (487 lbs./hr.), with the increase entirely attributable to the December tows. However, a comparison of Table 2 with the actual landings shows that a higher proportion of the "marketable" catch from the deep stations was discarded than from the shallower stations. Almost 8,000 lbs. of the marketable catch from the deep stations was comprised of whiting and butterfish, but only a little over 400 lbs. of these two species were landed. An examination of the length frequency data for the butterfish and whiting taken at the deep stations (Fig. 2) shows most of the catch consisted of fish of marginal size; butterfish enter the market at about 6" (15 cm) and whiting at about a foot (30 cm).

Longfin squid were by far the most important marketable species taken at the deep stations, with seven of twelve tows landed in December producting 500 lbs. or more (Table 2). The only other species to make a significant contribution was the porgy, and this species was primarily confined to two tows, one in March and one in December. The March tow (Sta. 48) was the only financially successful deep tow made during the first three months of the study, and even in this case there were so many spiny dogfish present that the catch was almost too large to land despite being of less than an hour's duration.

Inasmuch as only 18 successful tows were completed at depths of 100 fathoms or more it is not possible to draw any firm conclusions as to the optimal depths, times and areas for this type of fishing effort. Two facts do however stand out from this data 1) as the winter season progresses spiny dogfish become an increasing problem in this area if they are not to be landed, and 2) prior to the arrival of the dogifsh in January, squid are available in considerable quantity throughout the 100-200 fathom depth zone off Virginia. The chances of success for future fishing efforts in this region during the winter months would appear best if concentrated in the early months of the winter and directed specifically at squid.

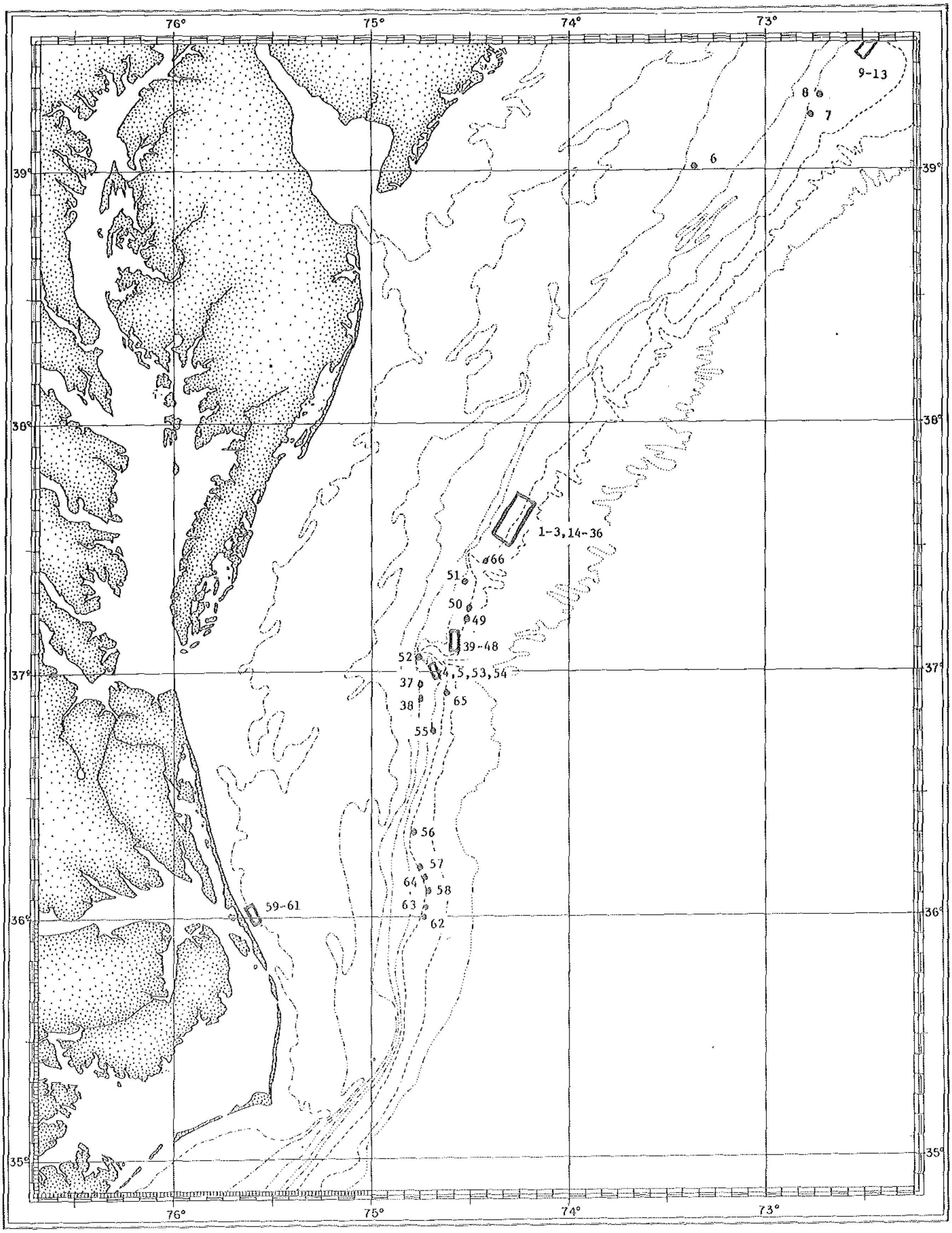


Figure 1.- Station locations.

TABLE 1.- Station information and catch data. Station time is hrs. EST, tow duration is in hours. Negative catches are tows aborted due to equipment failure or spiny dogfish fillups.

STA.	CRU.	DATE	TIME	POSITION		DEPTH FATH.	DUR. OF TOW	TOTAL CATCH LBS.	MARKETABLE CATCH LBS.	MARKETABLE CATCH /HR
1	VQ1	01/21/83	7.3	37°38.1′N	74°15.8′W	78	0.4	900	40	100
2	VQ1	01/21/83	8.5	37°37.7′N	74°15.0′W	113	1.0	900	55	55
3	VQ1	01/21/83	9.9	37°33.3′N	74°17.7′W	150	0.8	1500	260	325
4	VQ2	01/20/83	10.1	37°00.6′N	74°39.2′W	52	0.3	125	25	83
5	VQ2	01/25/83	10.9	37°00.2′N	74°37.6′W	52	0.6	-0	-0	-0
6	VQ2	01/26/83	9.1	39°02.4′N	73°21.2′W	41	0.6	150	140	233
7	VQ2	01/26/83	13.9	39°10.9′N	72°47.1′W	58	1.1	105	90	81
8	VQ2	01/26/83	16.7	39°15.0′N	72°44.5′W	60	1.5	290	225	150
9	VQ2	01/27/83	7.7	39°28.0′N	72°33.2′W	62	1.5	650	615	410
10	VQ2	01/27/83	9.4	39°26.5′N	72°30.3′W	63	1.0	610	605	605
11	VQ2	01/27/83	11.1	39°29.5′N	72°26.7′W	63	1.7	1210	1210	711
12	VQ2	01/27/83	13.5	39°27.7′N	72°29.4′W	61	2.0	275	270	135
13	VQ2	01/27/83	15.9	39°28.9′N	72°29.4′W	61	2.1	495	495	235
14	VQ2	01/29/83	11.5	37°41.0′N	74°20.0′W	51	0.8	500	500	625
15	VQ2	01/29/83	12.9	37°38.2′N	74°21.3′W	55	1.1	3670	3670	3336
16	VQ2	01/29/83	14.6	37°36.9′N	74°19.2′W	59	1.4	275	275	196
17	VQ2	01/29/83	16.7	37°38.0′N	74°19.5′W	54	1.4	3070	3070	2192
18	VQ2	01/29/83	18.1	37°40.1′N	74°18.8′W	56	0.7	2400	2400	3428
19	VQ2	01/29/83	19.7	37°40.0′N	74°18.9′W	54	1.6	1000	1000	625
20	VQ2	01/29/83	21.7	37°38.9′N	74°21.1′W	55	1.5	2330	2330	1553
21	VQ2	01/30/83	7.7	37°37.3′N	74°18.7′W	77	1.9	230	210	110
22	VQ2	01/30/83	9.8	37°38.6′N	74°14.3′W	109	1.1	3745	105	95
23	VQ2	01/30/83	13.8	37°35.2′N	74°23.6′W	50	1.7	620	620	364
24	VQ2	01/30/83	16.0	37°32.3′N	74°24.8′W	54	1.9	1130	1010	531
25	VQ2	01/30/83	18.8	37°29.4′N	74°27.0′W	51	2.4	620	580	241
26	VQ2	01/30/83	21.6	37°33.5′N	74°24.1′W	53	2.6	555	505	194
27	VQ2	01/31/83	0.2	37°33.3′N	74°24.5′W	51	2.5	790	650	260
28	VQ2	01/31/83	3.5	37°32.6′N	74°25.8′W	57	3.0	680	500	166
29	VQ2	01/31/83	6.5	37°33.2′N	74°25.8′W	52	2.8	950	830	296
30	VQ2	01/31/83	9.5	37°35.1′N	74°24.3′W	65	2.3	570	330	143
31	VQ2	01/31/83	10.7	37°34.9′N	74°18.4′W	152	1.0	240	240	240
32	VQ2	01/31/83	12.5	37°37.2′N	74°14.6′W	179	1.0	340	30	30
33	VQ2	01/31/83	14.8	37°40.1′N	74°19.9′W	51	0.8	-0	-0	-0
34	VQ2	01/31/83	19.1	37°34.8′N	74°23.6′W	51	2.7	980	860	318
35	VQ2	01/31/83	22.5	37°34.2′N	74°24.8′W	51	2.7	1000	900	333
36	VQ2	02/01/83	7.6	37°00.8′N	74°40.3′W	48	2.3	580	220	95
37	VQ2	02/01/83	10.0	36°58.2′N	74°45.4′W	40	1.6	380	380	237
38	VQ2	02/01/83	11.9	36°53.3′N	74°43.0′W	44	1.5	5060	260	173
39	VQ3	03/04/83	7.2	37°08.1′N	74°35.4′W	57	0.5	2560	2560	5120
40	VQ3	03/04/83	8.6	37°06.6′N	74°34.9′W	61	1.1	430	430	390
41	VQ3	03/04/83	9.9	37°06.9′N	74°34.7′W	82	0.7	7380	1380	1971
42	VQ3	03/04/83	11.8	37°06.1′N	74°36.2′W	60	1.0	605	605	605
43	VQ3	03/04/83	13.7	37°08.4′N	74°35.4′W	54	1.9	575	575	302
44	VQ3	03/04/83	15.3	37°07.7′N	74°35.5′W	55	2.7	730	730	270
45	VQ3	03/04/83	17.8	37°08.6′N	74°35.6′W	55	1.3	570	570	438

TABLE 1.- (con't.)

STA.	CRU.	DATE	TIME	POSITION		DEPTH FATH.	DUR. OF TOW	TOTAL CATCH LBS.	MARKETABLE CATCH LBS.	/HR
46	VQ3	03/05/83	7.6	37°08.6'N	74°34.8'W	57	1.1	400	400	363
47	VQ3	03/05/83	9.0	37°05.4'N	74°34.9'W	76	0.8	-0	-0	-0
48	VQ3	03/05/83	10.7	37°09.3'N	74°33.2'W	118	0.8	6030	2430	3037
49	VQ3	03/05/83	11.6	37°11.8'N	74°32.3'W	104	0.6	-0	-0	-0
50	VQ3	03/05/83	13.3	37°14.2'N	74°31.4'W	115	0.5	-0	-0	-0
51	VQ3	03/05/83	16.7	37°21.2'N	74°31.3'W	55	0.5	2450	50	100
52	VQ3	03/06/83	11.2	37°04.1'N	74°45.5'W	50	0.6	240	240	399
53	VQ3	03/06/83	13.0	37°00.4'N	74°39.7'W	55	0.4	1385	185	462
54	VQ3	03/06/83	14.0	36°57.9'N	74°38.1'W	94	0.5	6180	180	360
55	VQ3	03/06/83	16.9	36°47.2'N	74°41.0'W	64	0.8	540	540	675
56	VC4	12/06/83	11.3	36°19.3'N	74°45.8'W	162	2.0	-0	-0	-0
57	VC4	12/06/83	15.3	36°06.3'N	74°46.6'W	159	2.5	2200	1720	688
58	VC4	12/06/83	18.0	36°01.8'N	74°47.0'W	145	2.0	985	865	432
59	VC4	12/06/83	9.5	37°20.0'N	75°35.0'W	5	2.0	850	600	300
60	VC4	12/07/83	13.0	36°00.0'N	75°35.0'W	5	2.0	1340	1320	660
61	VC4	12/07/83	16.9	36°00.0'N	75°35.0'W	5	2.1	900	870	414
62	VC4	12/08/83	8.0	35°58.5'N	74°47.2'W	200	3.0	630	540	180
63	VC4	12/08/83	12.2	36°04.0'N	74°47.7'W	142	2.8	3450	2940	1049
64	VC4	12/08/83	15.2	36°08.4'N	74°47.1'W	103	2.5	2400	1080	432
65	VC5	12/13/83	7.6	36°53.0'N	74°43.0'W	145	2.5	1640	440	176
66	VC5	12/13/83	16.2	36°30.8'N	74°22.3'W	87	2.5	2360	1640	656
67	VC5	12/13/83	18.7	37°31.8'N	74°21.8'W	97	1.5	2490	1470	980
68	VC5	12/14/83	8.9	37°35.3'N	74°15.9'W	152	3.2	5080	4480	1400
69	VC5	12/14/83	14.6	37°36.4'N	74°22.5'W	102	3.2	3020	2270	709
70	VC5	12/15/83	16.9	37°36.4'N	74°22.5'W	113	3.2	950	830	259
71	VC5	12/15/83	19.2	37°37.4'N	74°22.5'W	113	2.3	740	620	269

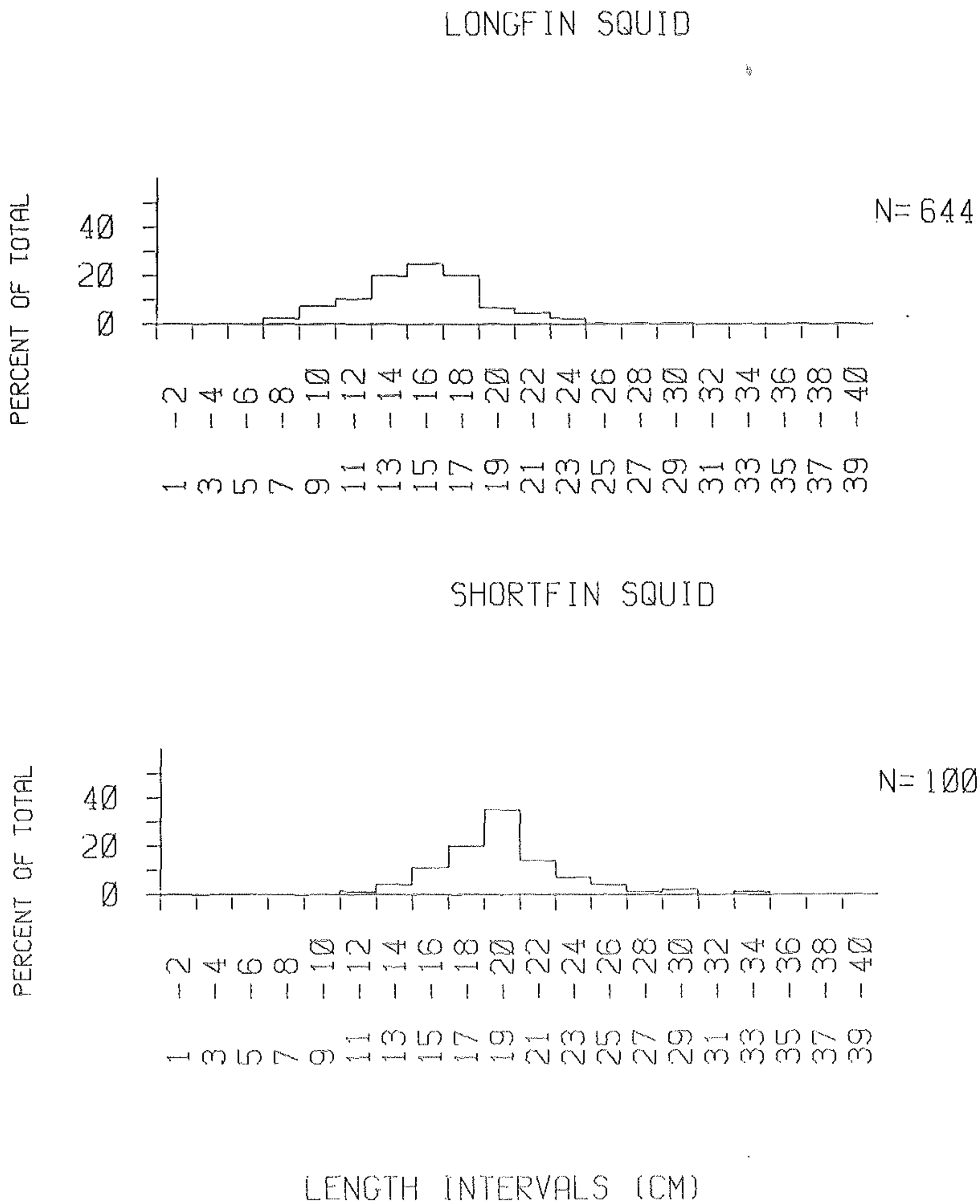
TABLE 2.- Catch breakdown for stations in which at least part of tow was deeper than 100 fathoms.

CRU.	STA.	DEPTH FATH.	MARKETABLE CATCH LBS.	LONGFIN SQUID	BUTTERFISH	PORGIES	WHITING
VQ1	2	113	55	10			20
VQ1	3	150	260				150
VQ2	22	109	105				70
VQ2	31	152	240	50			110
VQ2	32	179	30	5			20
VQ3	48	118	2430			2400	
VQ3	49	104	~0				
VQ3	50	115	~0				
VC4	56	162	~0				
VC4	57	159	1720		120		1440
VC4	58	145	865				865
VC4	62	200	540				420
VC4	63	142	2940	2880	30		
VC4	64	103	1080	960			120
VC5	65	145	440	200			
VC5	66	87	1640	1280	120		240
VC5	67	97	1470	1050			360
VC5	68	152	4480	1200	3000	60	
VC5	69	102	2270	800	240	840	240
VC5	70	113	830	500	180		90
VC5	71	113	620	300	60		
			22,015	9,235	3,750	3,300	4,145

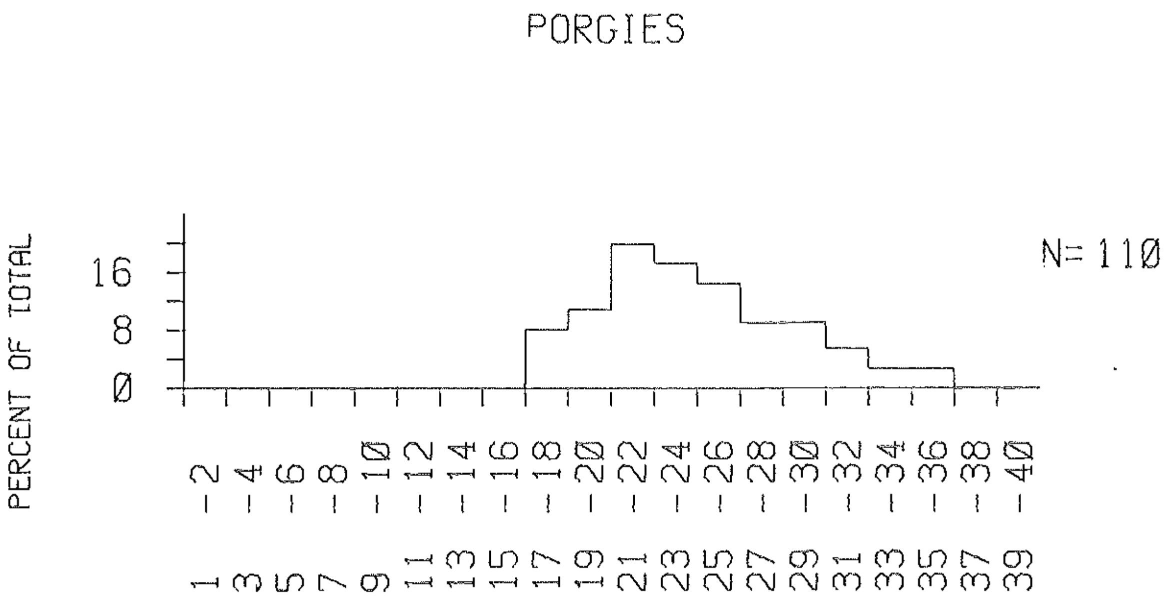
Other marketable species taken:

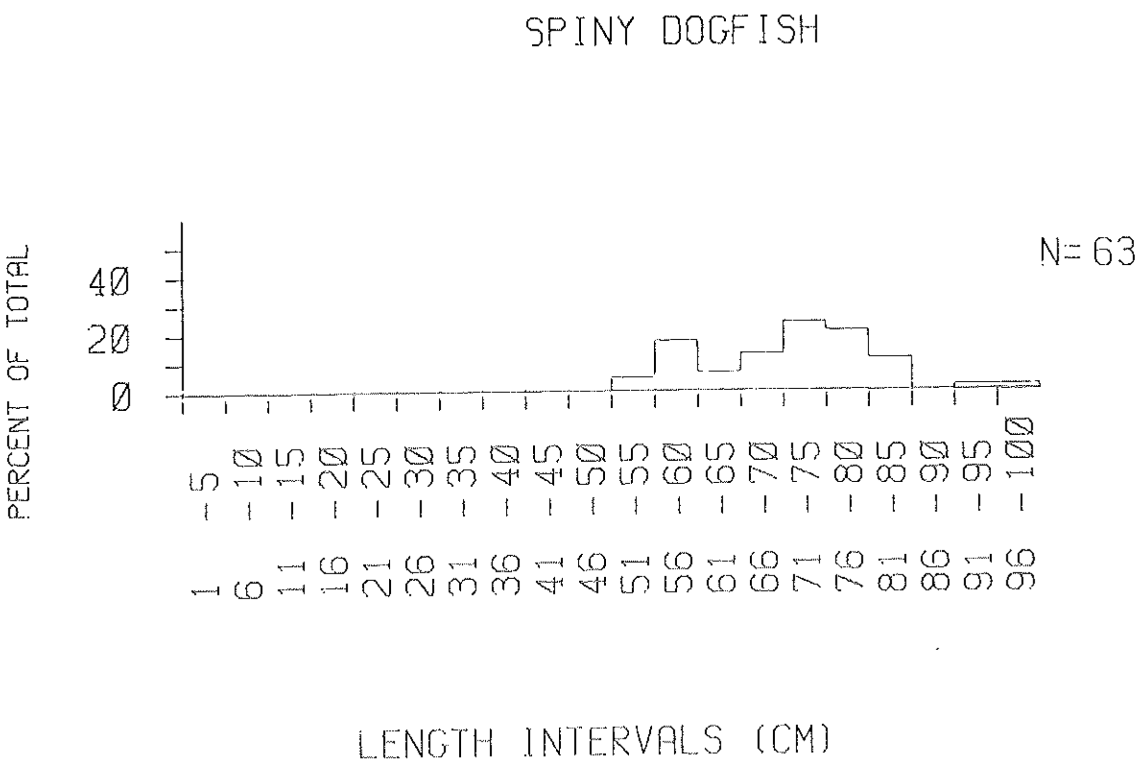
Shortfin Squid	385	lbs.
Monkfish	390	"
Bluefish	240	"
Black Seabass	150	"
Grey Sole	130	"
Summer Flounder	65	"

APPENDIX 1



Appendix Figure 1.- Length frequencies of longfin and shortfin squid, porgies, spiny dogfish, red and spotted hake, monkfish, bluefish and grey sole taken at stations of 100 fathoms or greater.





Appendix Figure 1.- (con't.)

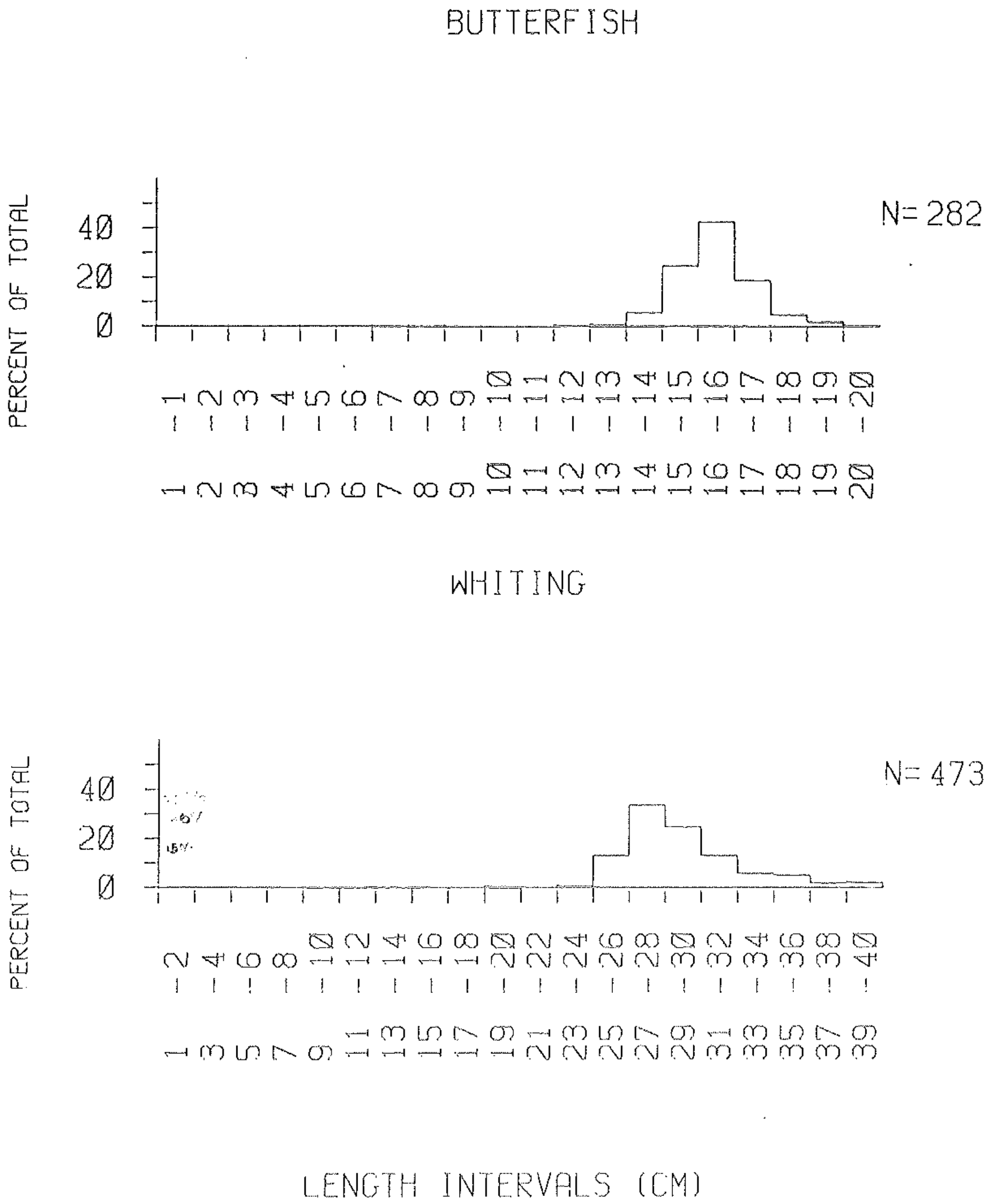
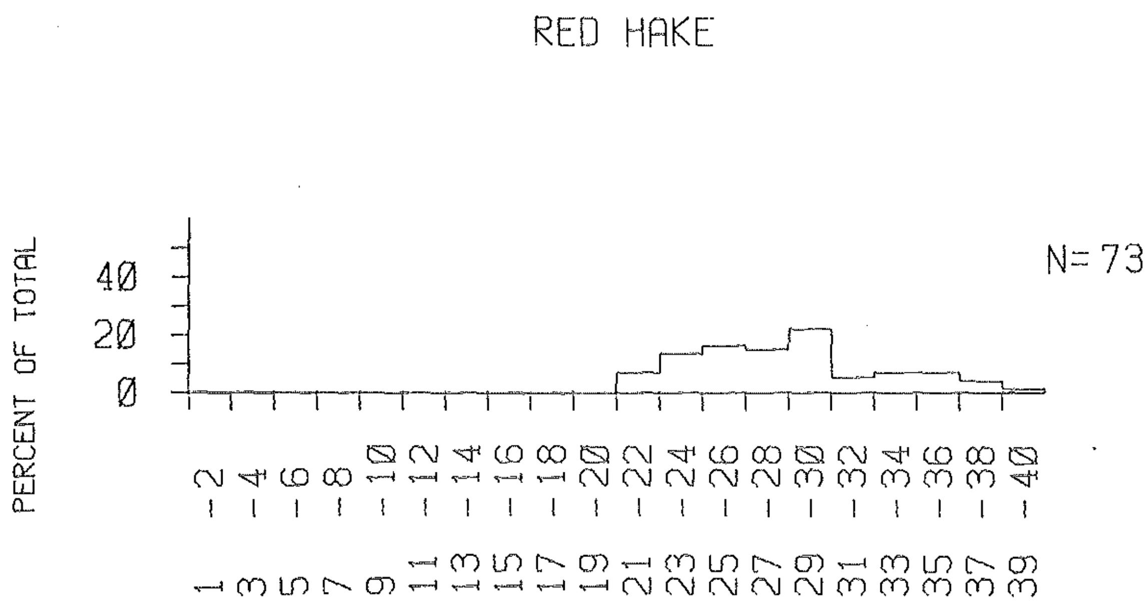
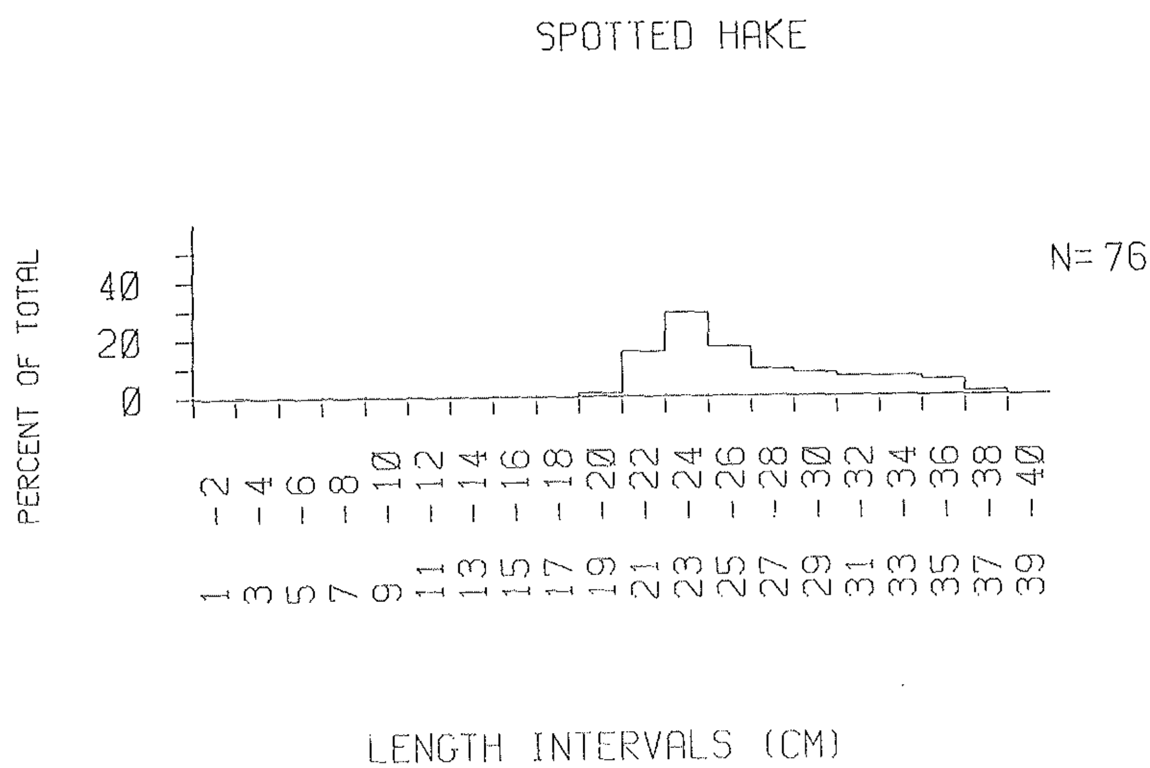
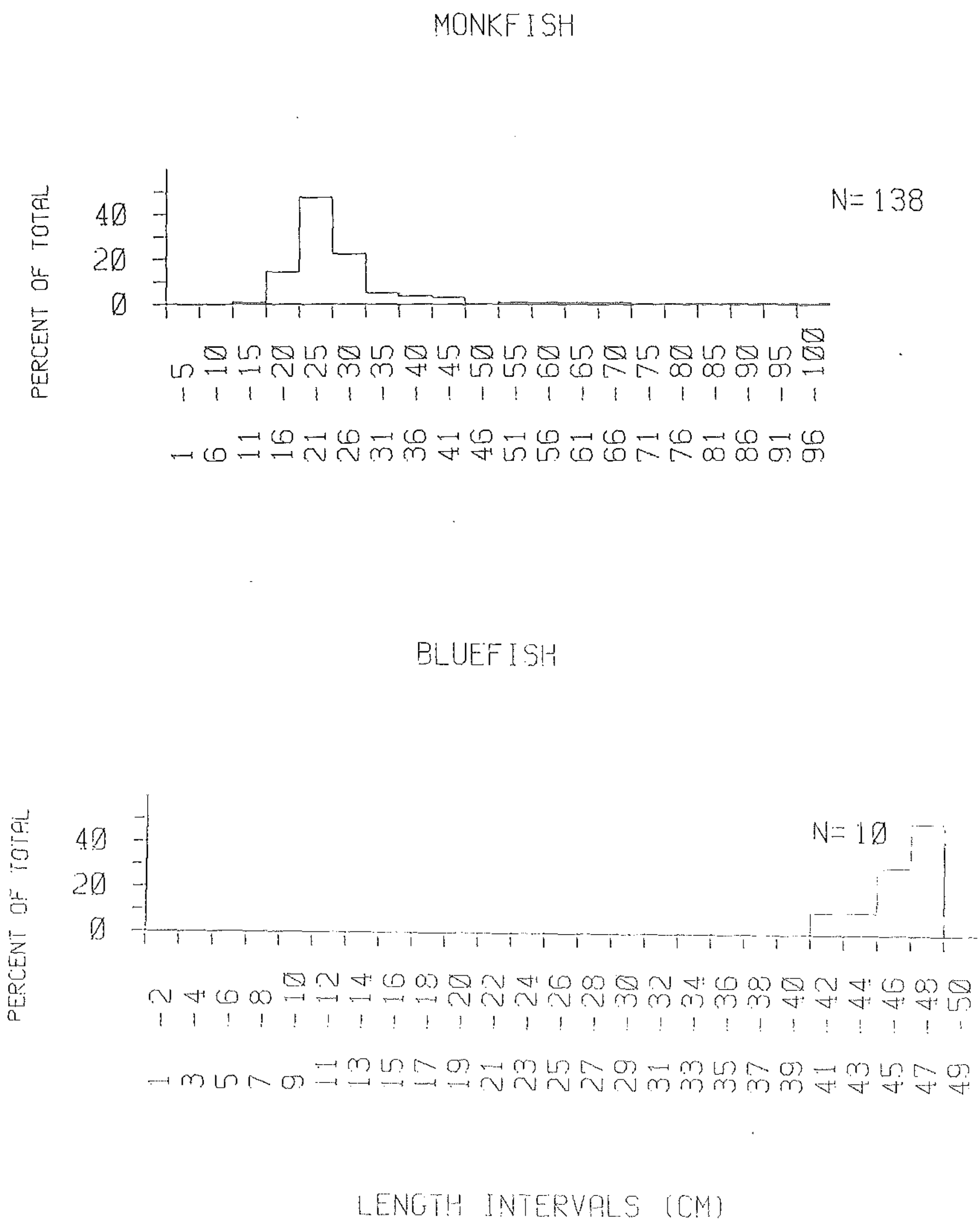


Figure 2.- Length frequencies of butterfish and whiting from stations deeper than 100 fathoms.

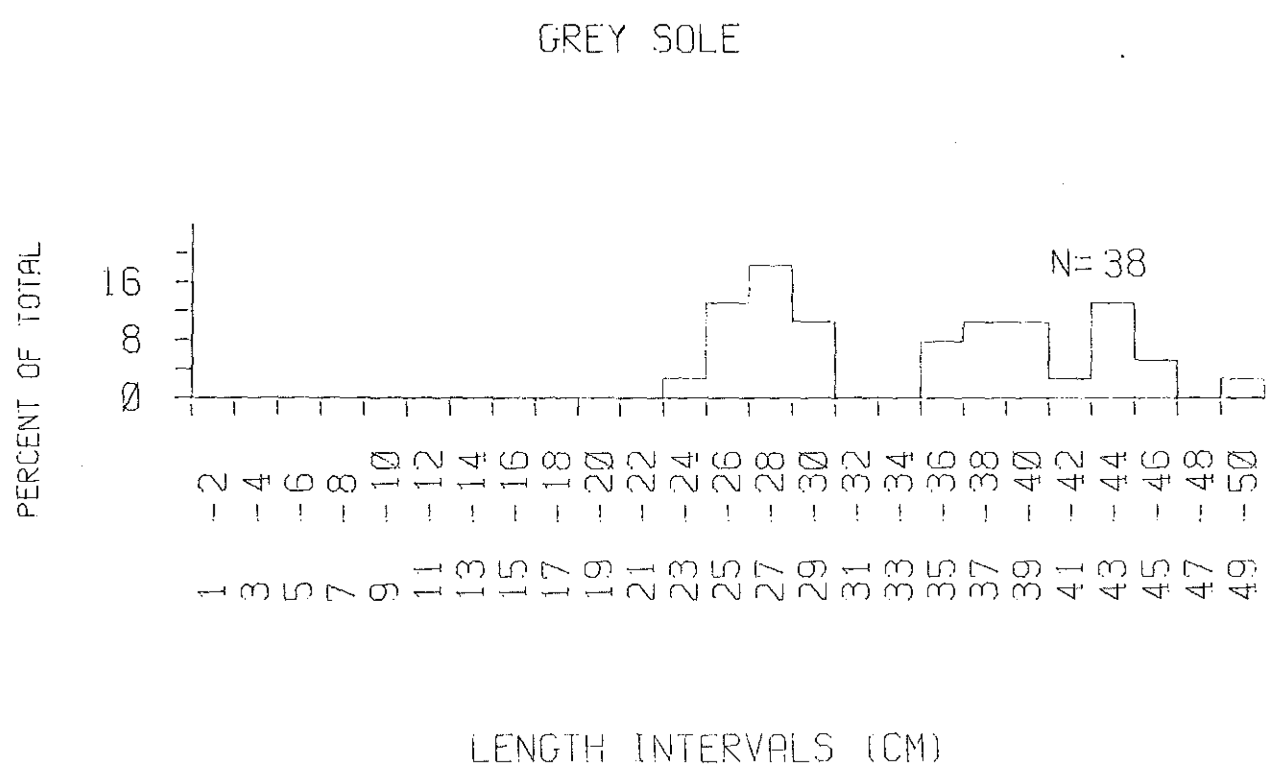




Appendix Figure 1.- (con't.)



Appendix Figure 1.- (con't.)



Appendix Figure 1.- (con't.)

APPENDIX 2

Appendix Two Overview

Prior to the commencement of project field activities, historical data taken by fisheries research vessels trawling in the target area was reviewed to determine whether optimal trawling areas, depths or times could be identified. The National Marine Fisheries Service has conducted a semi-annual trawl survey of the Atlantic continental shelf which has included stations of over 100 fathoms in the Chesapeake Bight area since 1967. These surveys are conducted in the spring (Mar.-Apr.) and fall (Sept.-Nov.). During the fall cruises from 1967 to 1972 Soviet research vessels participated in the effort.

All NMFS tows made at depths greater than 80 fathoms in the Chesapeake Bight between 1967 and 1980 were included in the analysis (n=280). Additionally, 47 tows (80-325 fathoms) made in the Norfolk Canyon area during four seasonal deep-sea research cruises conducted by the Virginia Institute of Marine Science during 1973-1976 were included. The data was prepared for rapid visual analysis by preparing two-dimensional scattergrams of catches vs. latitude and depth. These plots were further broken down by season, gear, day vs. night and species (Appendix 2) and then examined for evident trends.

No strong latitudinal patterns were evident. Large catches occurred sporadically throughout the study area, and while some areas seemed to produce more large hauls the variation was very high and no area was consistently more productive than another. Determination of optimal depths was hampered by the fact the NMFS surveys went only to about 200 fathoms, and the small amount of data available for the

200-300 fathom range was all collected with the smaller net used during the VIMS cruises. Most species appeared to be fairly evenly distributed with depth, but squid and butterfish were clearly more abundant in the 100-130 fathom range.

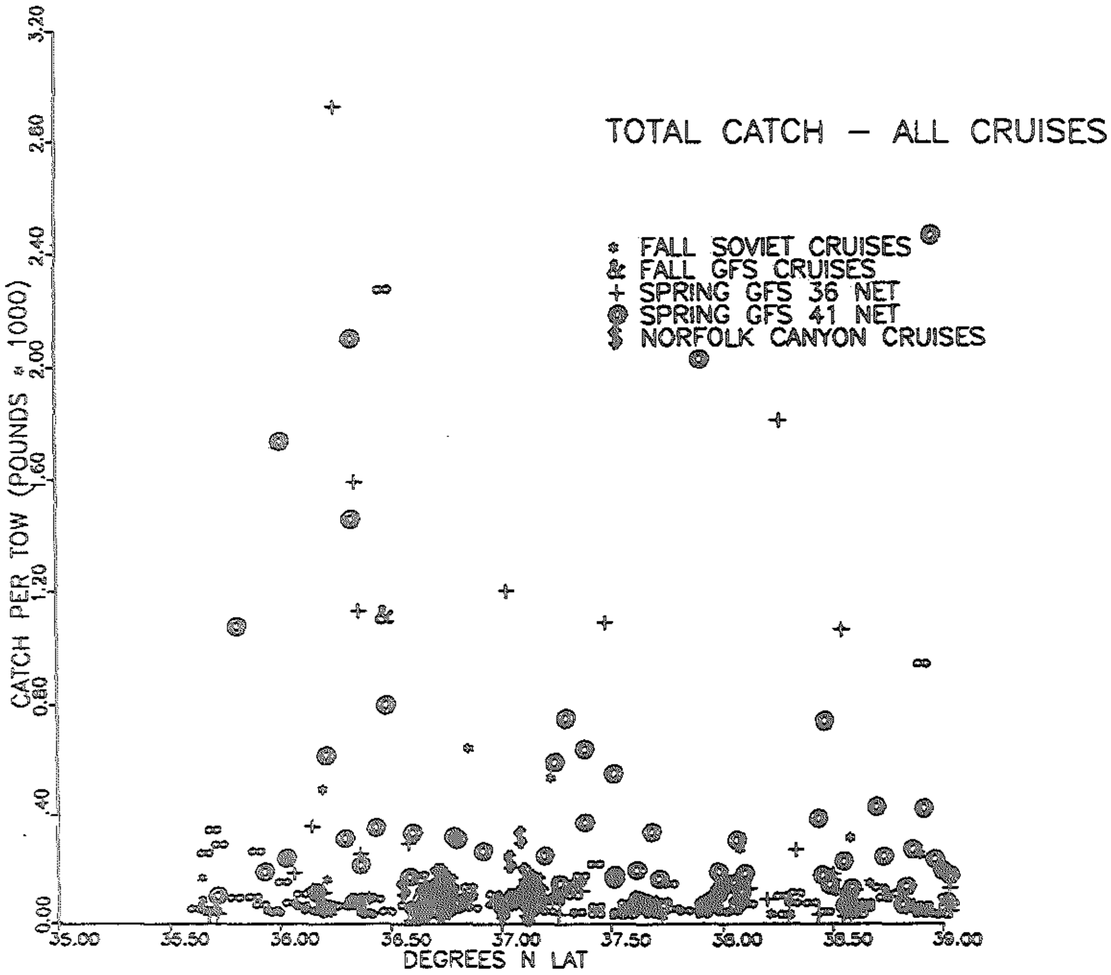
Except for 10 tows made in January during a VIMS cruise, all of the available data was taken outside of the winter study period. Fortunately, the NMFS data does bracket this period, and inferences could be drawn in the absence of more direct information. Spiny dogfish strongly dominated the spring catches but were virtually absent during the fall cruises. No other major species showed such a pronounced change. Direct comparison of fall and spring catch rates is difficult due to net differences, but whiting and monkfish were obviously more abundant during the spring cruises while butterfish and the squid species appear more plentiful during the fall. The latter group also showed the only clear day/night differences, with bottom trawl catch reates being consistently higher during the day (particularly during the fall), reflecting a nocturnal migration upward into the water column.

APPENDIX 2.- Historical research vessel trawl catch data from the study area (Cape May to Cape Hatteras, deeper than 80 fathoms). Data collected by the National Marine Fisheries Service (1967-1980) and the Virginia Institute of Marine Science (1973-1976). NMFS data was collected in the fall (Sept.-Nov.) using a Yankee 36 trawl (52′ headrope) and a Soviet 27.1 Meter trawl (89′ headrope) and in the spring (Mar.-Apr.) using both a Yankee 36 (1967-1972) and a Yankee 41 (79′ headrope, 1973-1980) trawl. VIMS trawls were all made in the immediate vicinity of Norfolk Canyon using a 45′ otter trawl during four cruises, once in each season. All tows were of 30 min. duration. Data is presented graphically and is broken down on the following variables: latitude, depth, season, gear, day/night and by species.

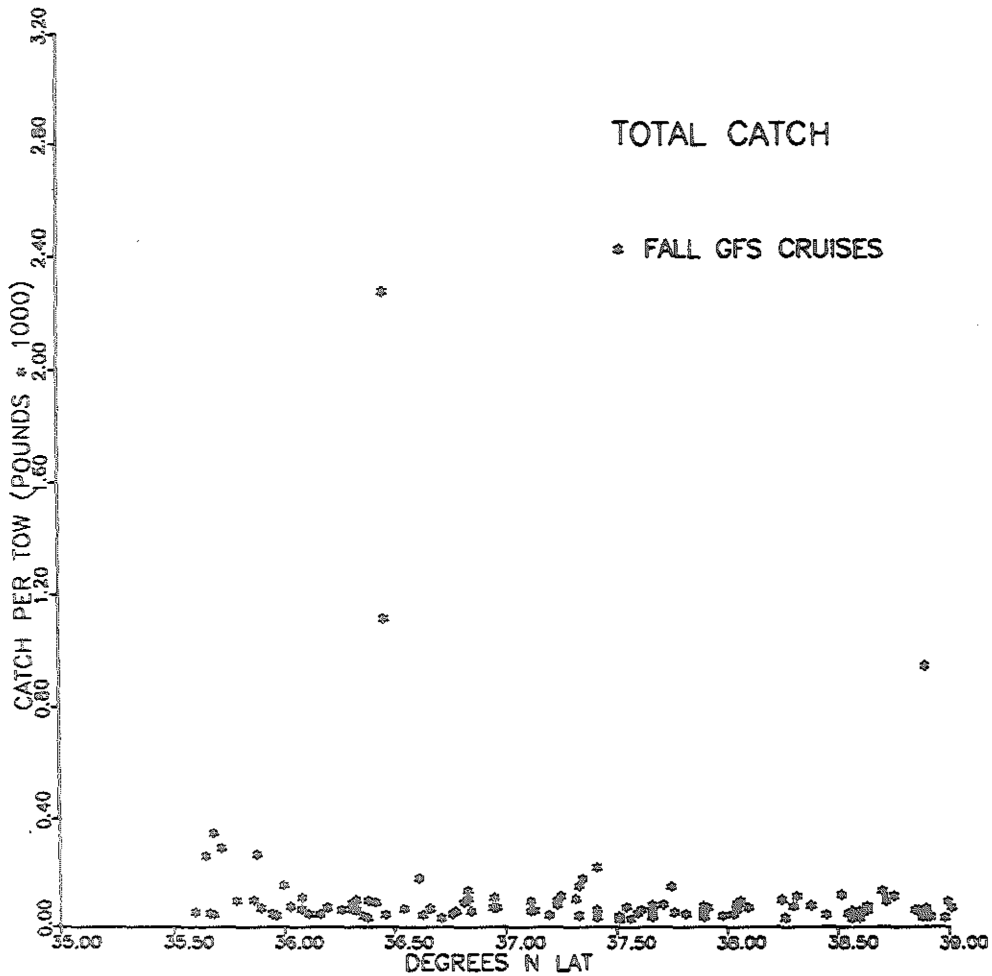
Appendix Figure 2-1. Total catch (fish and edible invertebrates) by latitude, season and gear.
2-2. Total catch by latitude for fall NMFS cruises, Yankee 36 trawl.
2-3. Total catch by latitude for fall NMFS cruises, Soviet 27.1 trawl.
2-4. Total catch by latitude for spring NMFS cruises, Yankee 36 trawl.
2-5. Total catch by latitude for spring NMFS cruises, Yankee 41 trawl.
2-6. Total catch by latitude for VIMS Norfolk Canyon cruises.
2-7. Total catch by latitude and season for VIMS Norfolk Canyon cruises (expanded scale).
2-8. Total catch by latitude, season and day/night.
2-9. Total catch by latitude for fall day stations.
2-10. Total catch by latitude for fall night stations.
2-11. Total catch by latitude for spring day stations.
2-12. Total catch by latitude for spring night stations.
2-13. Total catch (excluding spiny dogfish) by latitude for all cruises.
2-14. Total catch (excluding spiny dogfish) by latitude and season.
2-15. Total catch (excluding spiny dogfish) by latitude for fall stations.
2-16. Total catch (excluding spiny dogfish) by latitude for spring stations.
2-17. Total catch (excluding spiny dogfish) by latitude for fall day stations.
2-18. Total catch (excluding spiny dogfish) by latitude for fall night stations.
2-19. Total catch (excluding spiny dogfish) by latitude for spring day stations.
2-20. Total catch (excluding spiny dogfish) by latitude for spring night stations.
2-21. Catch by latitude of spiny dogfish for all cruises.
2-22. Catch by latitude of spiny dogfish for fall day stations.

Appendix Figure 2-23. Catch by latitude of spiny dogfish for fall night stations.
2-24. Catch by latitude of spiny dogfish for spring day stations.
2-25. Catch by latitude of spiny dogfish for spring night stations.
2-26. Catch by latitude of whiting for all cruises.
2-27. Catch by latitude of whiting for fall day stations.
2-28. Catch by latitude of whiting for fall night stations.
2-29. Catch by latitude of whiting for spring day stations.
2-30. Catch by latitude of whiting for spring night stations.
2-31. Catch by latitude of longfin squid for all cruises.
2-32. Catch by latitude of longfin squid for fall day stations.
2-33. Catch by latitude of longfin squid for fall night stations.
2-34. Catch by latitude of longfin squid for spring day stations.
2-35. Catch by latitude of longfin squid for spring night stations.
2-36. Catch by latitude of shortfin squid for all cruises.
2-37. Catch by latitude of shortfin squid for fall day stations.
2-38. Catch by latitude of shortfin squid for fall night stations.
2-39. Catch by latitude of shortfin squid for spring day stations.
2-40. Catch by latitude of shortfin squid for spring night stations.
2-41. Catch by latitude of butterfish for all cruises.
2-42. Catch by latitude of butterfish for fall day stations.
2-43. Catch by latitude of butterfish for fall night stations.
2-44. Catch by latitude of butterfish for spring day stations.
2-45. Catch by latitude of butterfish for spring night stations.
2-46. Catch by latitude of monkfish for all cruises.
2-47. Catch by latitude of monkfish for fall cruises.
2-48. Catch by latitude of monkfish for spring cruises.
2-49. Catch by latitude of offshore hake for all cruises.
2-50. Catch by latitude of red hake for all cruises.
2-51. Catch by latitude of spotted hake for all cruises.
2-52. Catch by latitude of blackbelly rosefish for all cruises.
2-53. Catch by latitude of grey sole for all cruises.
2-54. Catch by latitude of American lobster for all cruises.

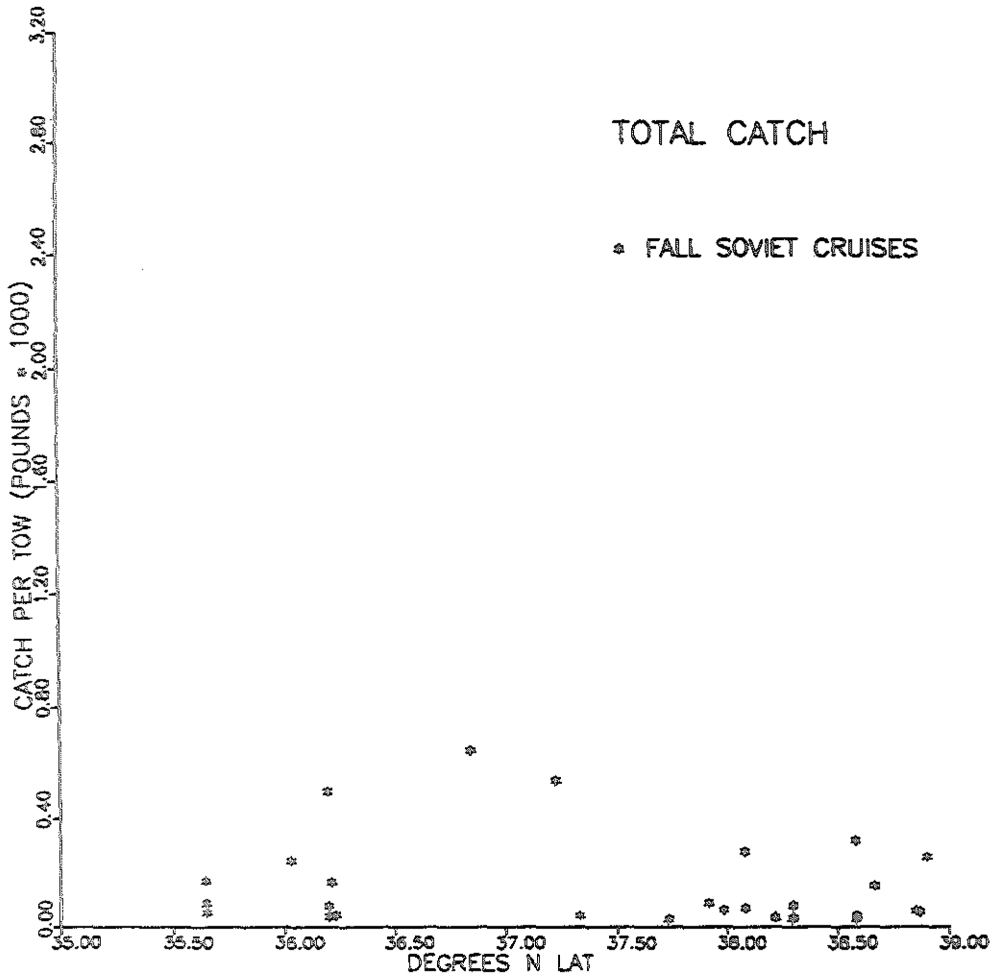
Appendix Figure 2-55. Catch by latitude of American lobster for all cruises (expanded scale).
2-56. Total catch (fish and edible invertebrates) by depth, season and gear.
2-57. Catch by depth of spiny dogfish for all cruises.
2-58. Catch by depth of spiny dogfish for spring day stations.
2-59. Catch by depth of spiny dogfish for spring night stations.
2-60. Catch by depth of longfin squid for all cruises.
2-61. Catch by depth of shortfin squid for all cruises.
2-62. Catch by depth of whiting for all cruises.
2-63. Catch by depth of whiting for fall day stations.
2-64. Catch by depth of whiting for fall night stations.
2-65. Catch by depth of whiting for spring day stations.
2-66. Catch by depth of whiting for spring night stations.
2-67. Catch by depth of butterfish for all cruises.
2-68. Catch by depth of monkfish for spring cruises.



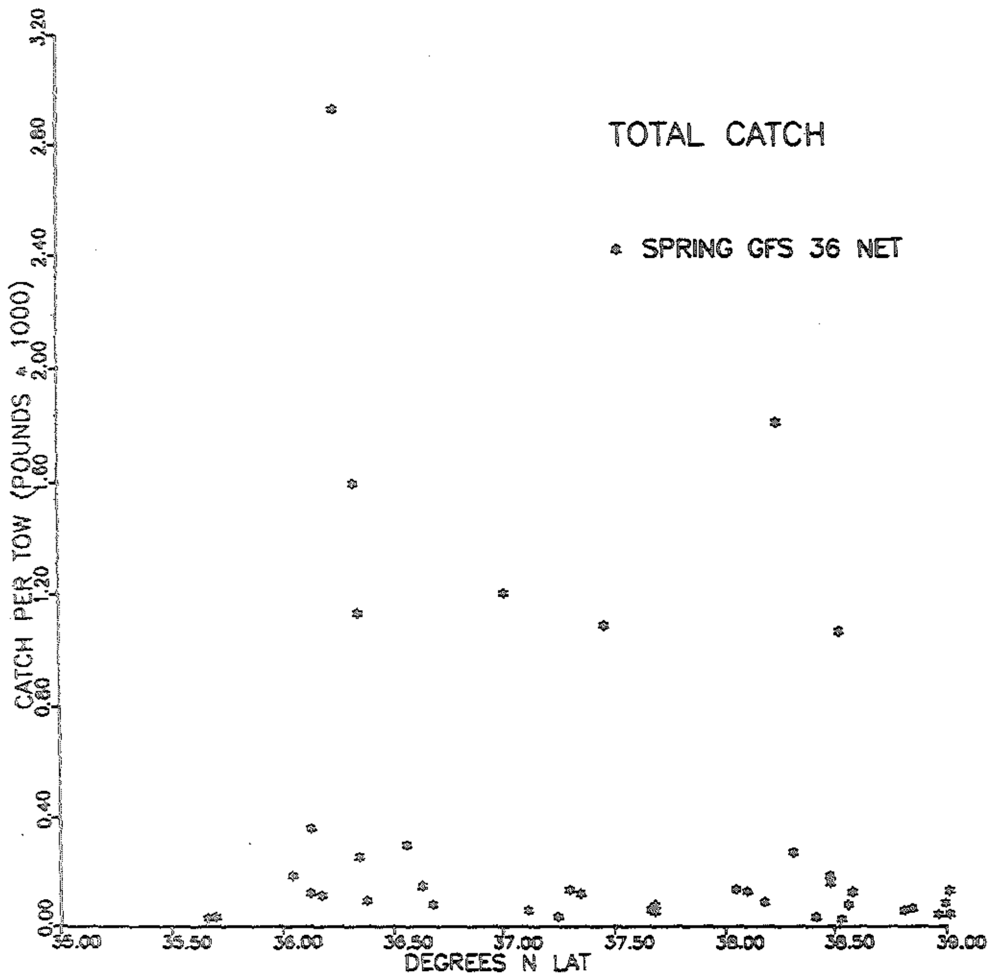
Appendix Figure 2-1. Total catch (fish and edible invertebrates) by latitude, season and gear.



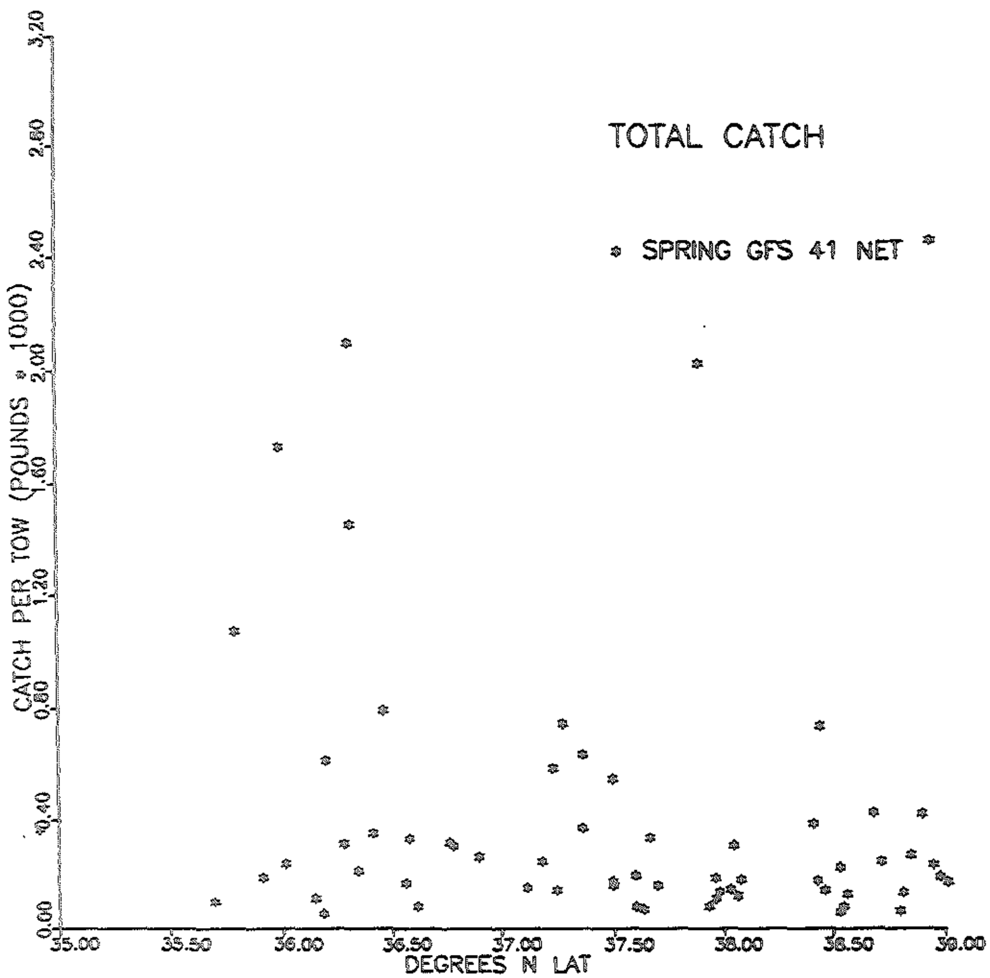
Appendix Figure 2-2. Total catch by latitude for fall NMFS cruises, Yankee 36 trawl.



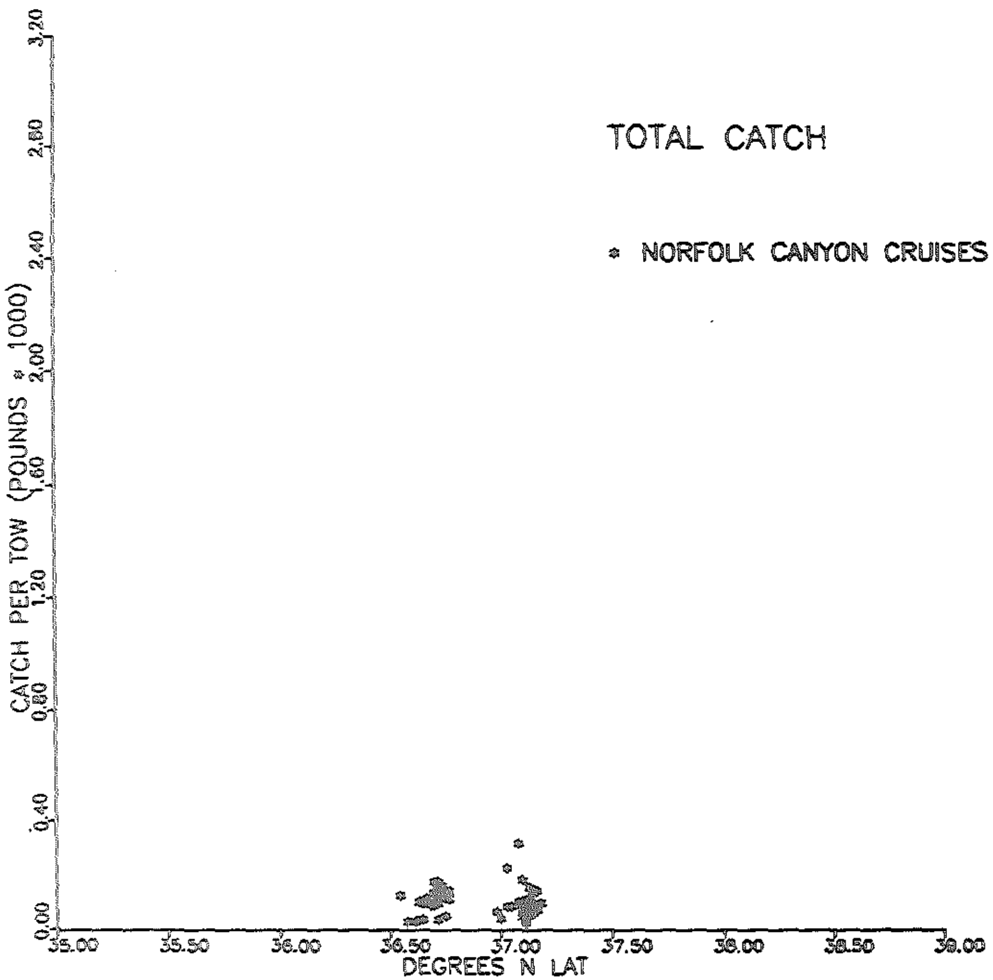
Appendix Figure 2-3. Total catch by latitude for fall NMFS cruises, Soviet 27.1 trawl.



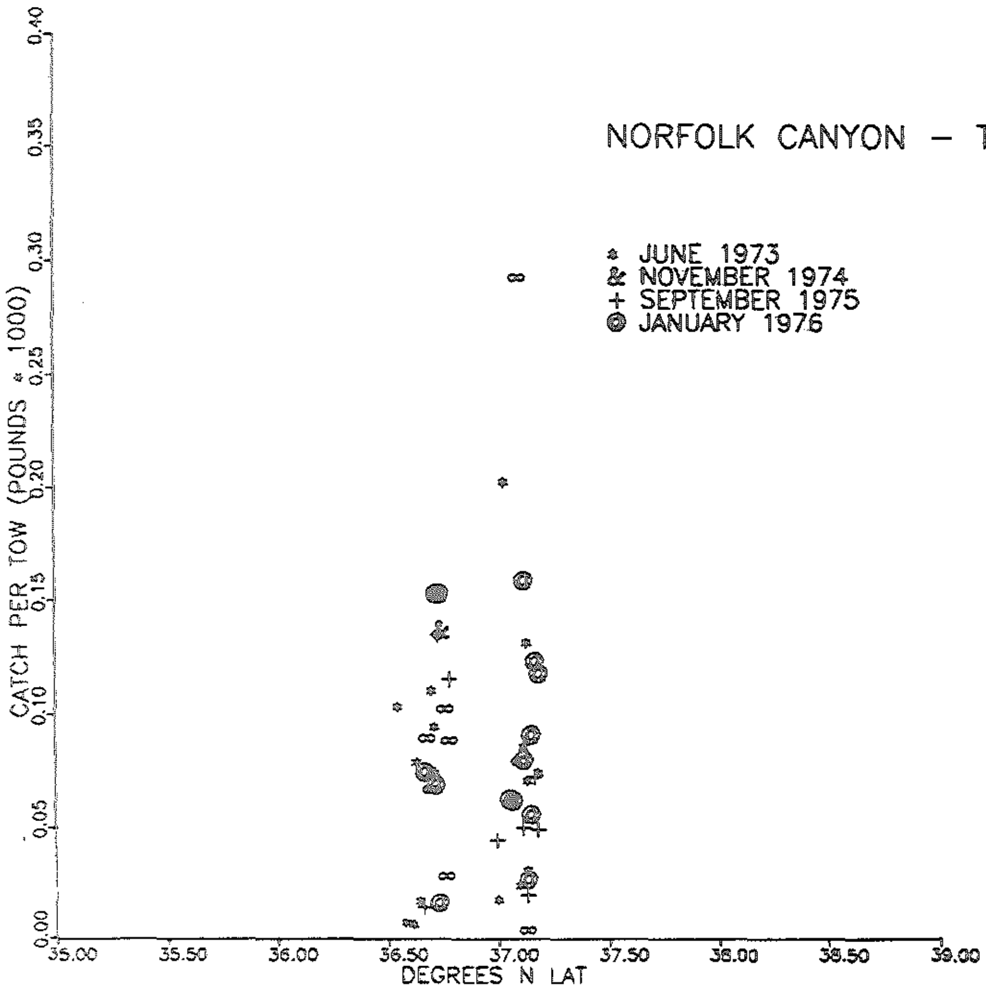
Appendix Figure 2-4. Total catch by latitude for spring NMFS cruises, Yankee 36 trawl.



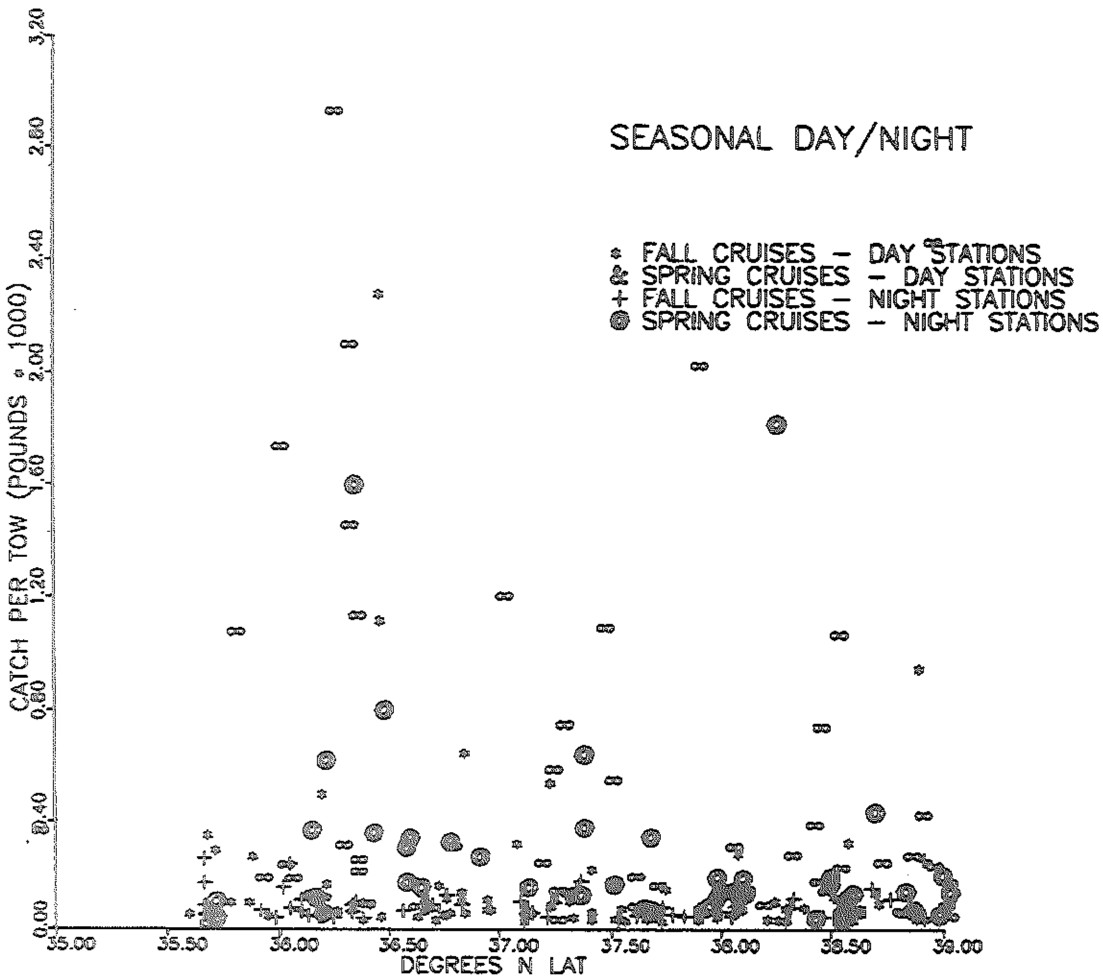
Appendix Figure 2-5. Total catch by latitude for spring NMFS cruises, Yankee 41 trawl.



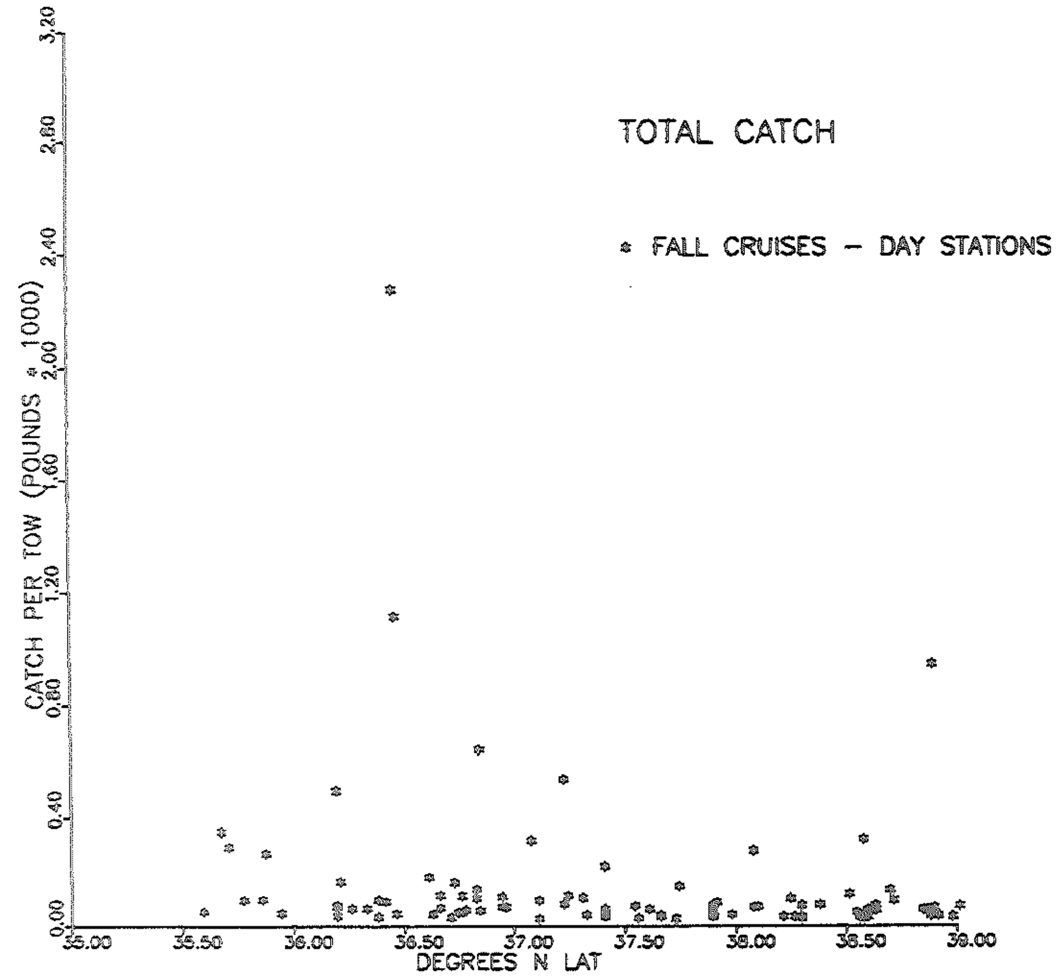
Appendix Figure 2-6. Total catch by latitude for VIMS Norfolk Canyon cruises.



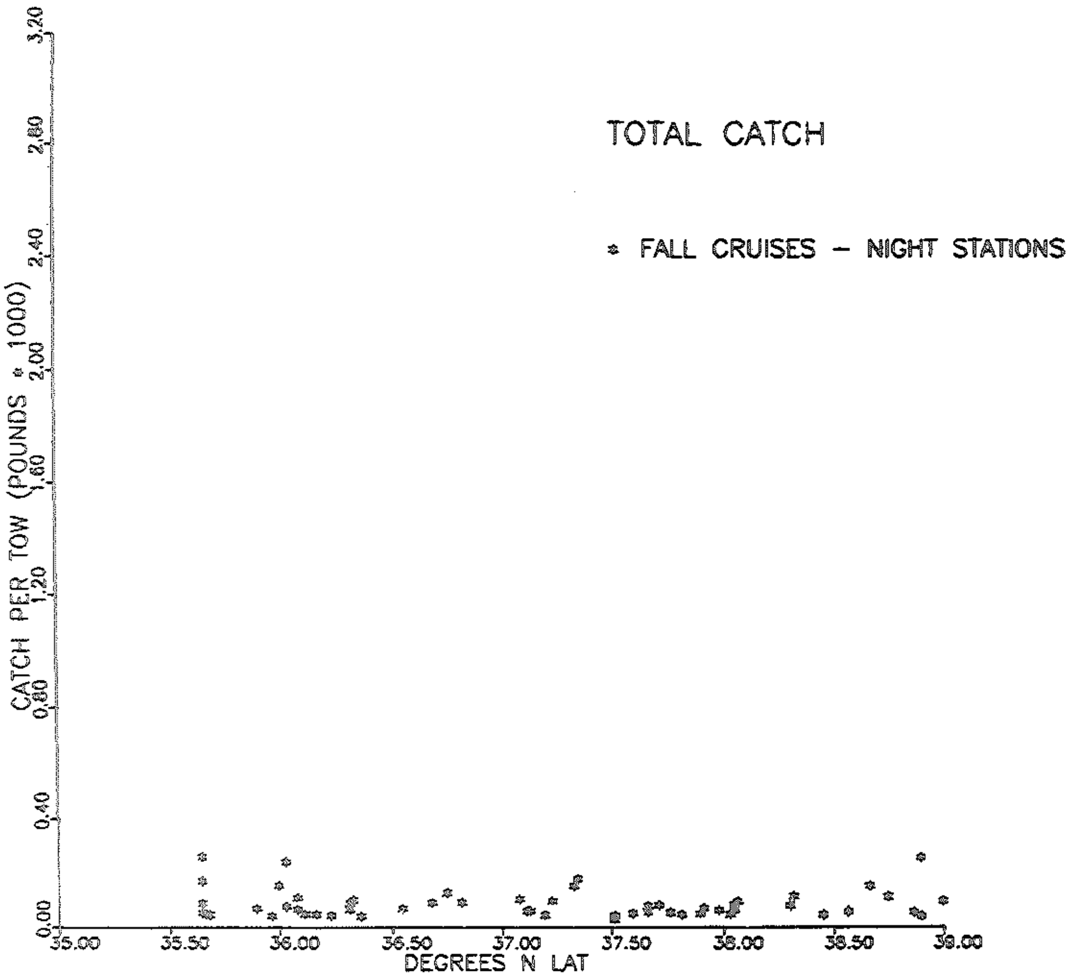
Appendix Figure 2-7. Total catch by latitude and season for VIMS Norfolk Canyon cruises (expanded scale.



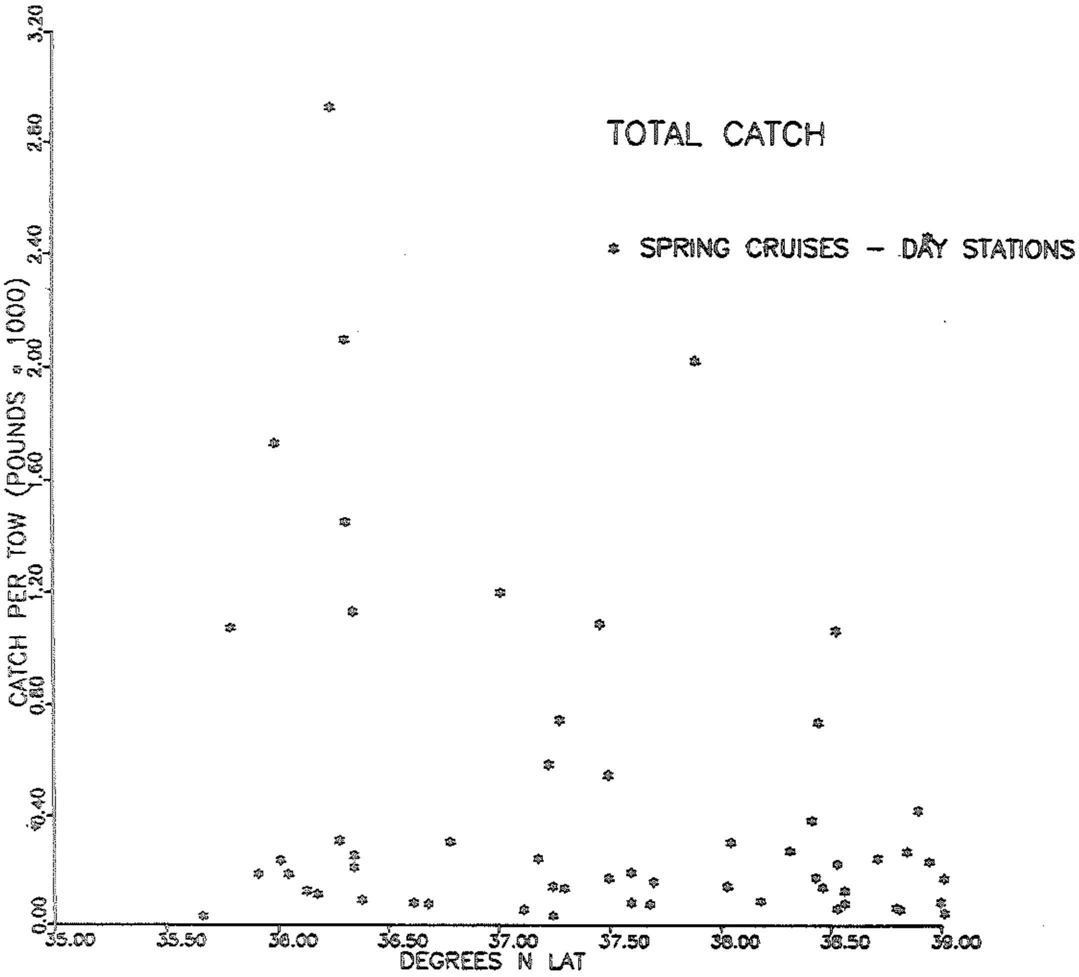
Appendix Figure 2-8. Total catch by latitude, season and day/night.



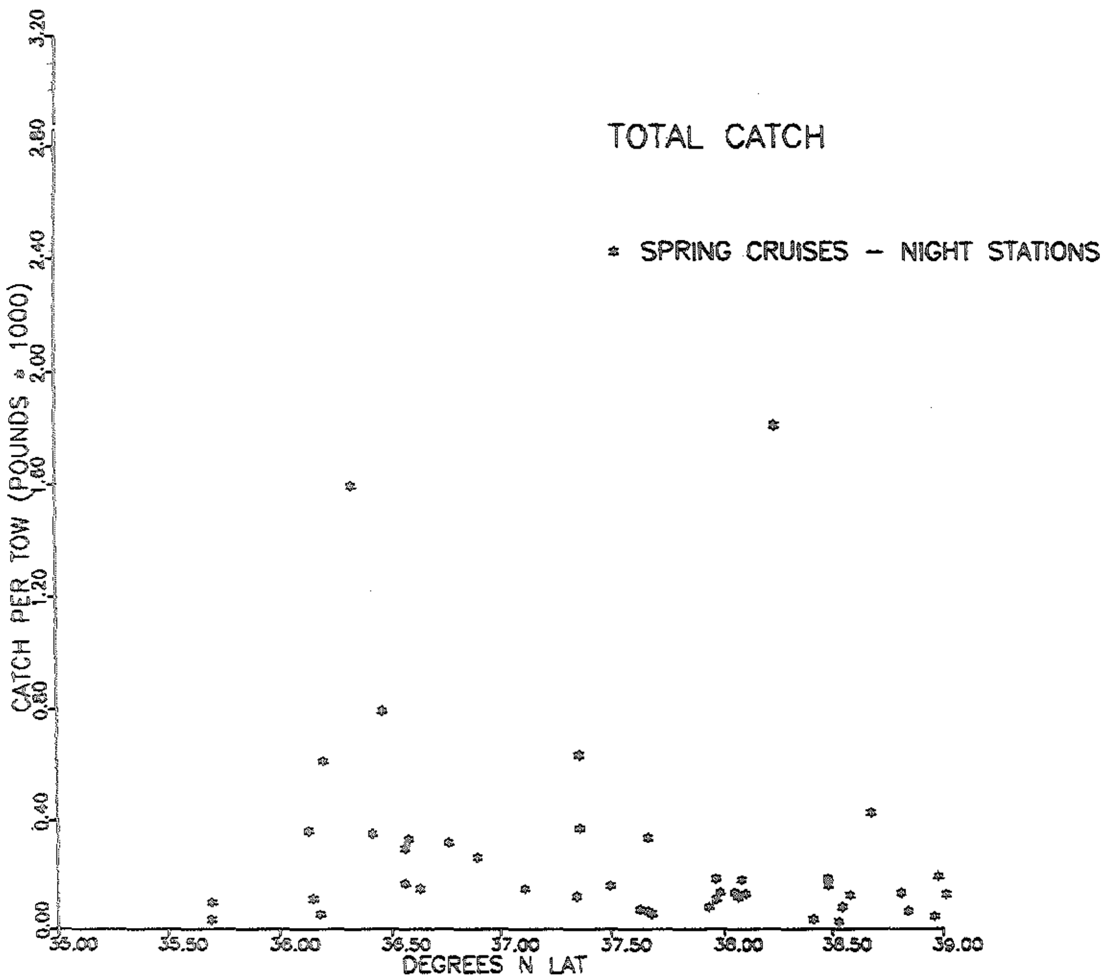
Appendix Figure 2-9. Total catch by latitude for fall day stations.



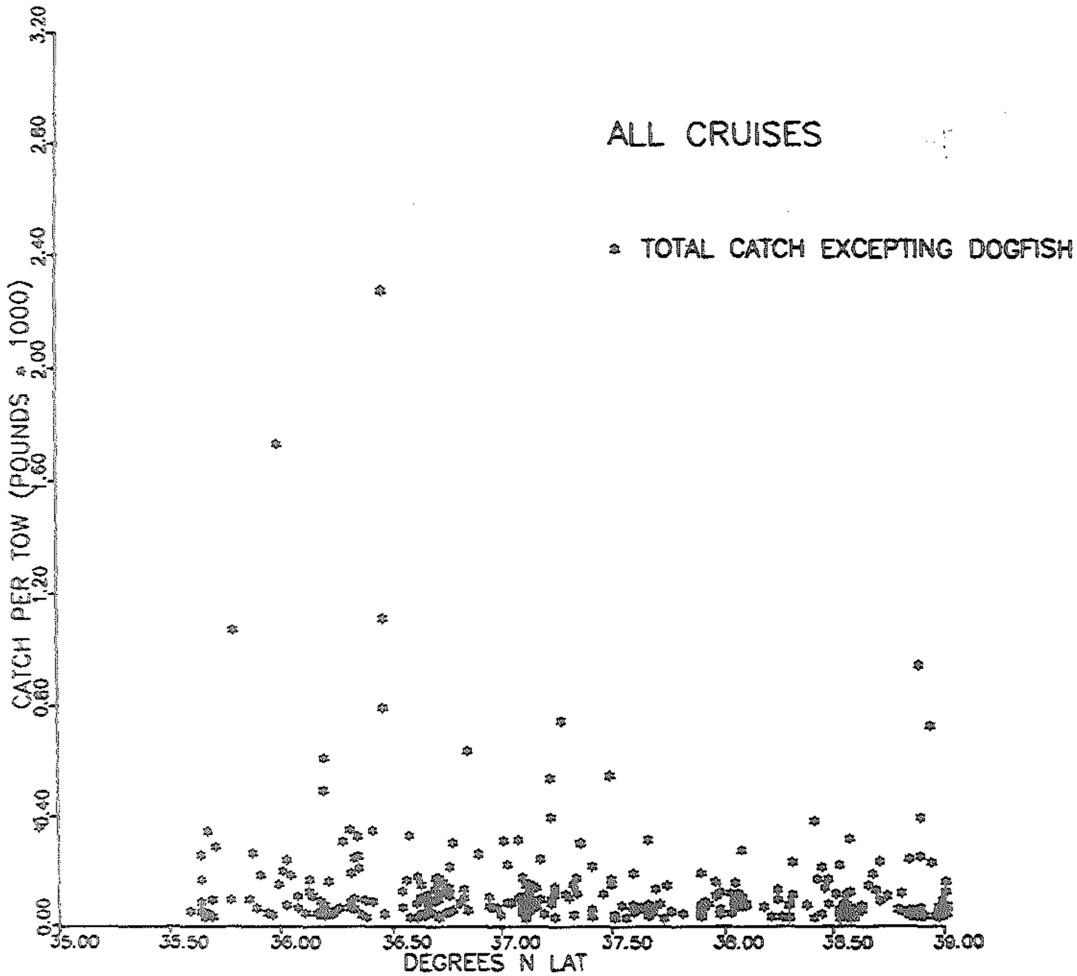
Appendix Figure 2-10. Total catch by latitude for fall night stations.



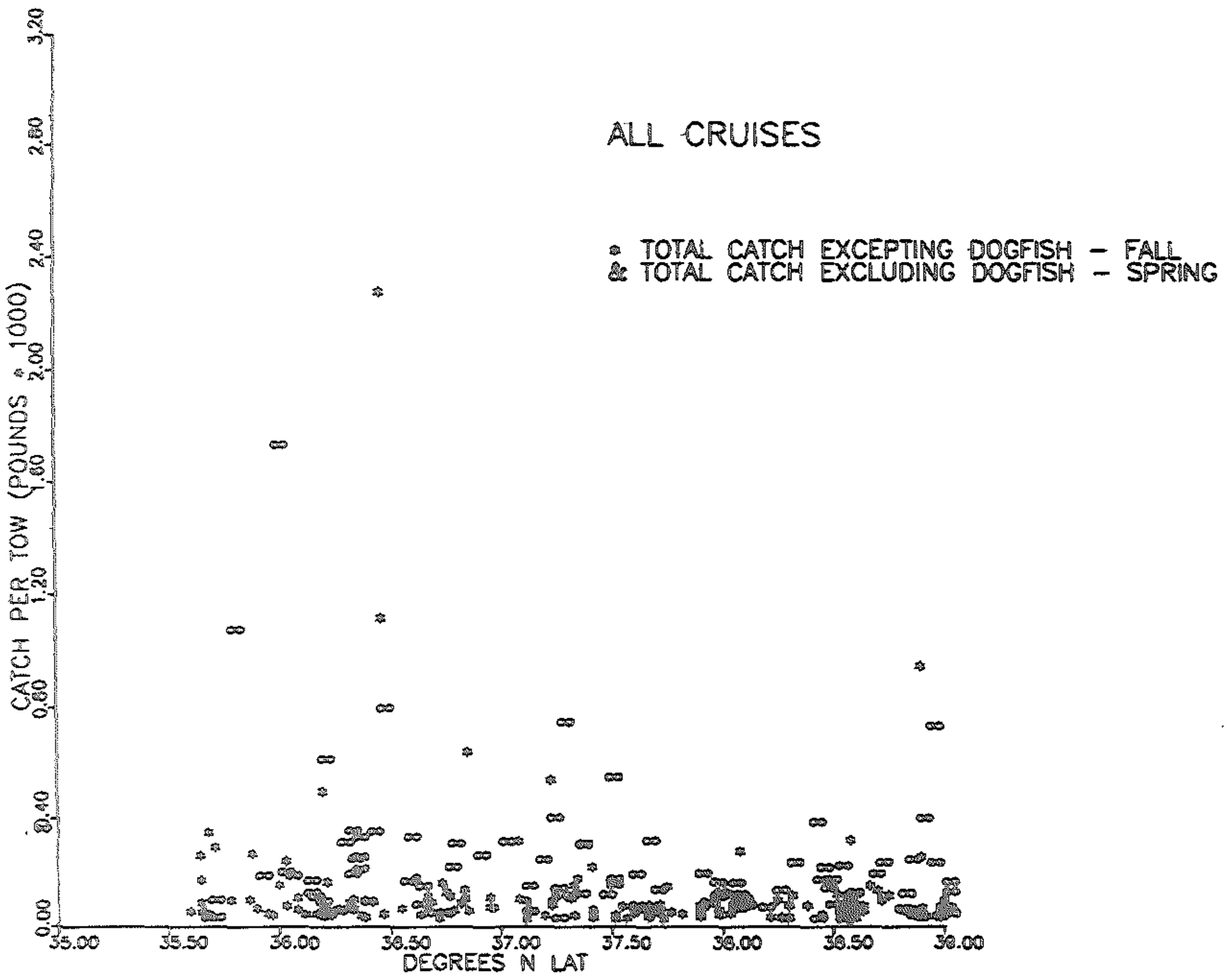
Appendix Figure 2-11. Total catch by latitude for spring day stations.



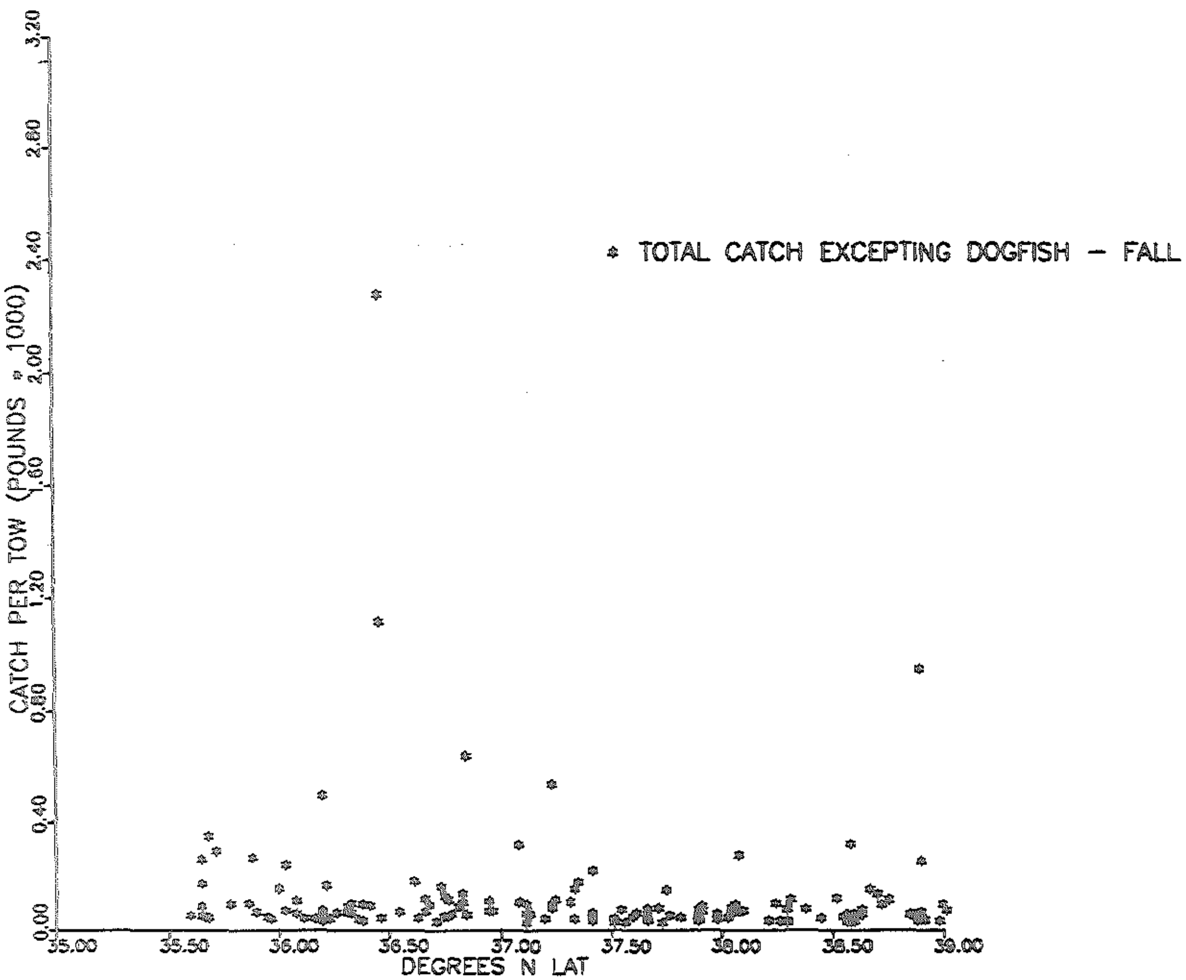
Appendix Figure 2-12. Total catch by latitude for spring night stations.



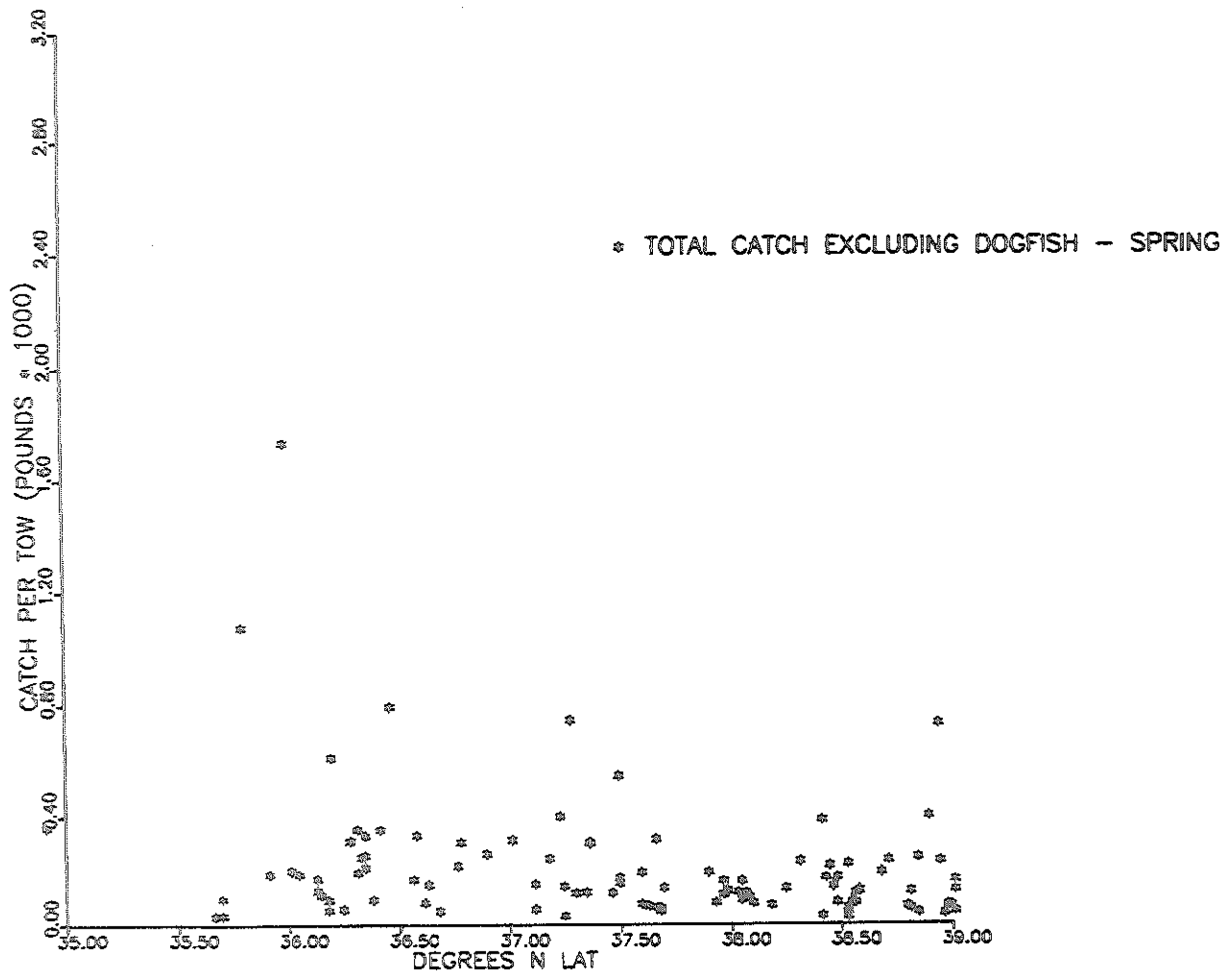
2-13. Total catch (excluding spiny dogfish) by latitude for all cruises.



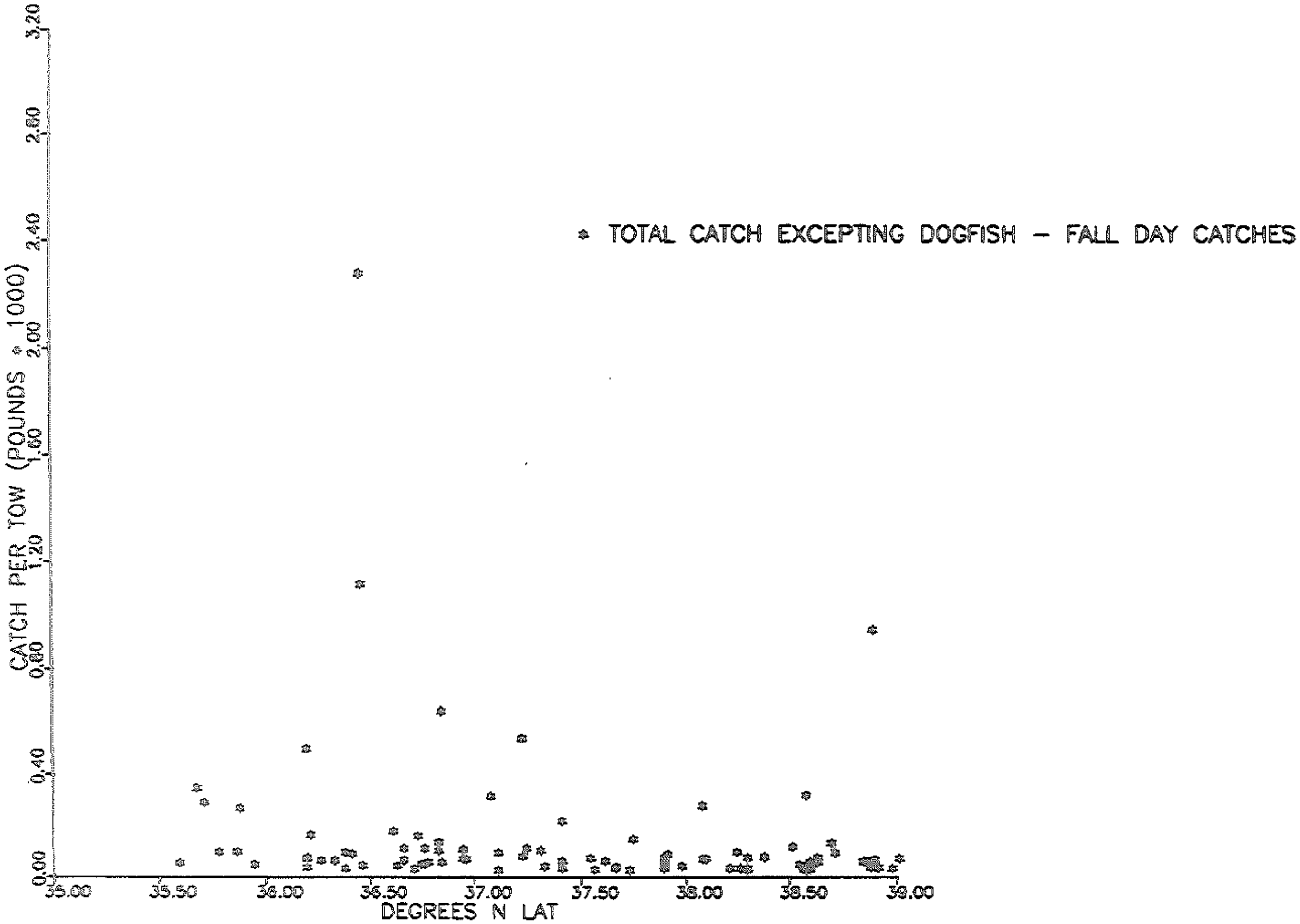
2-14. Total catch (excluding spiny dogfish) by latitude and season.



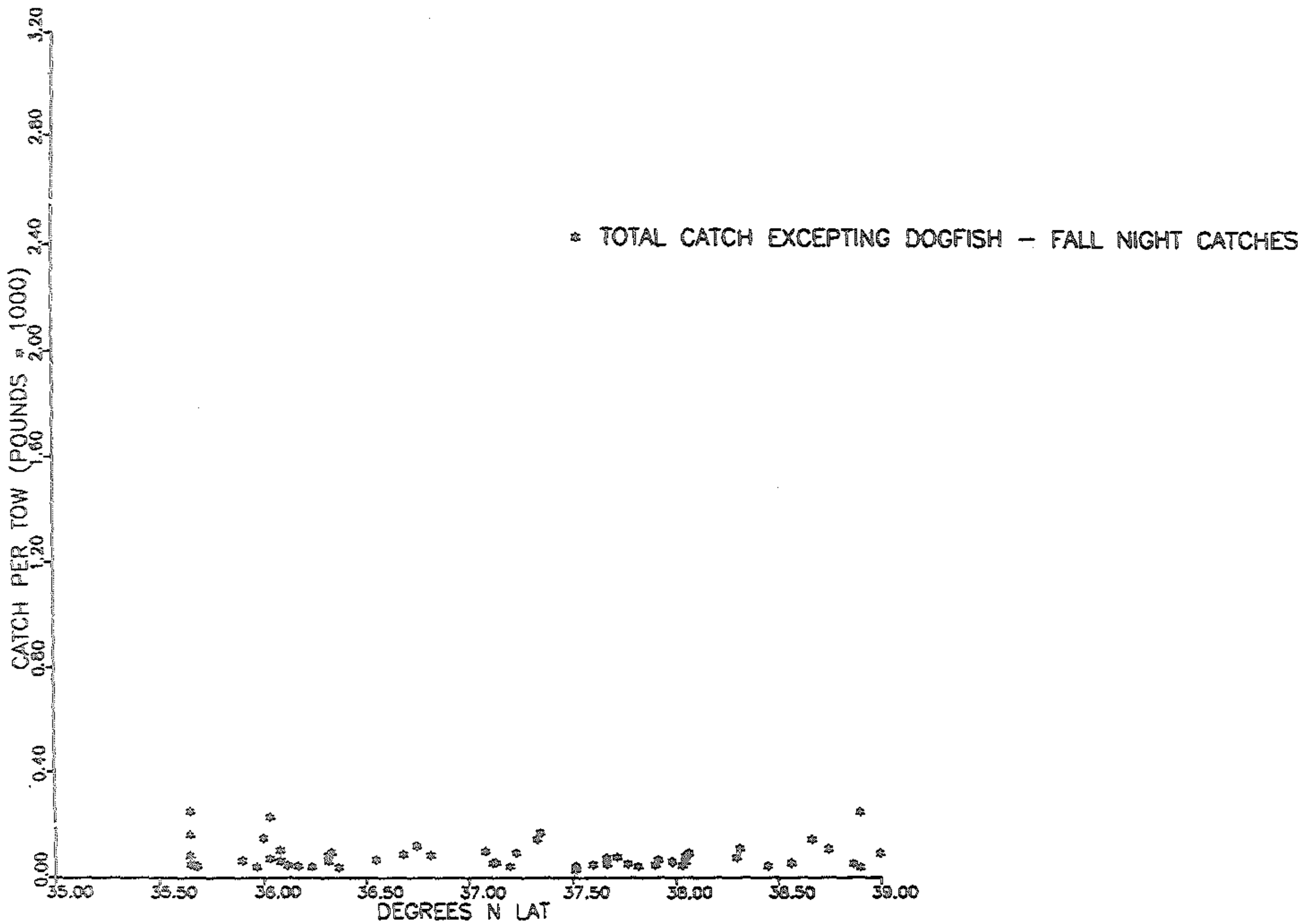
Appendix Figure 2-15. Total catch (excluding spiny dogfish) by latitude for fall stations.



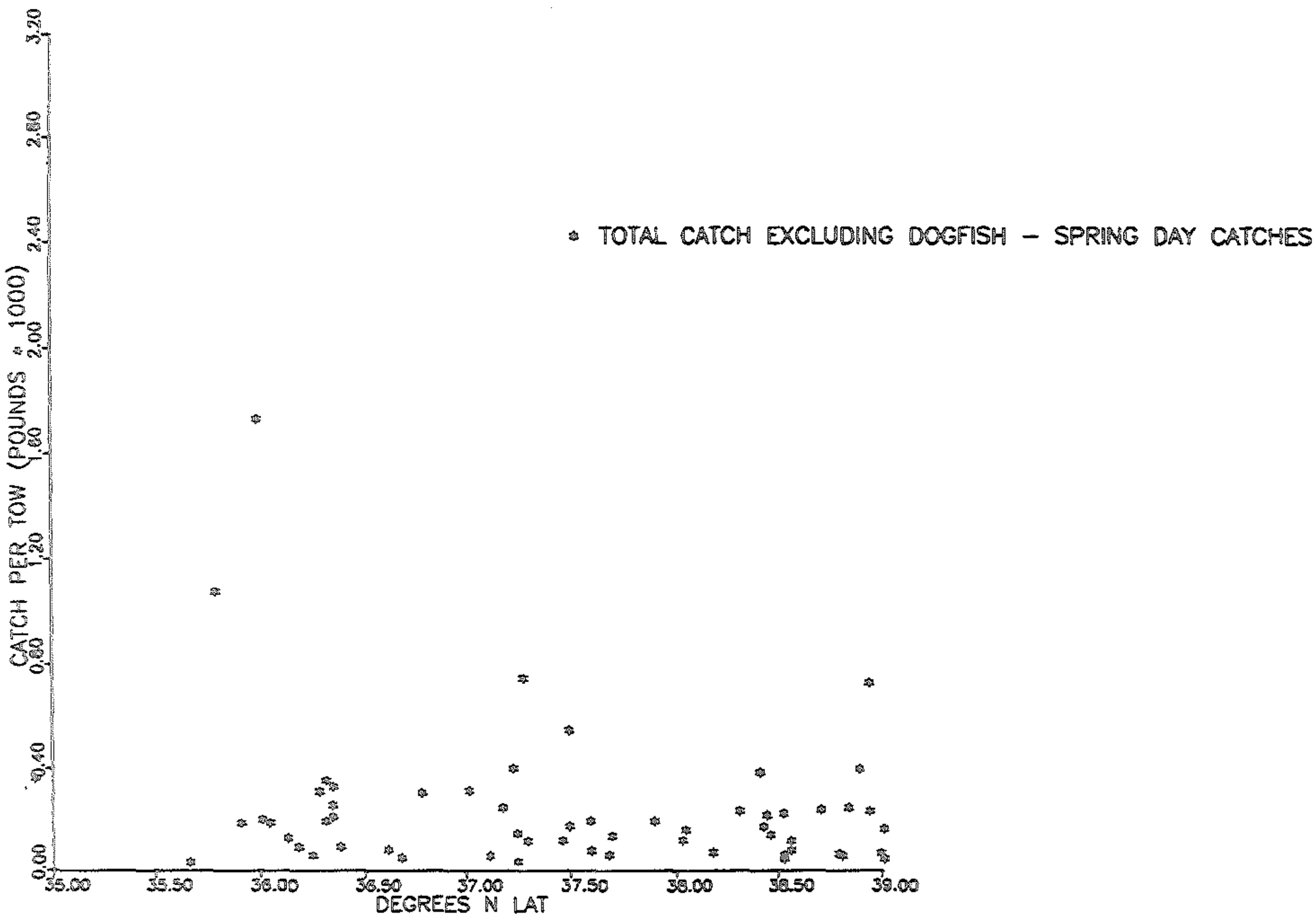
Appendix Figure 2-16. Total catch (excluding spiny dogfish) by latitude for spring stations.



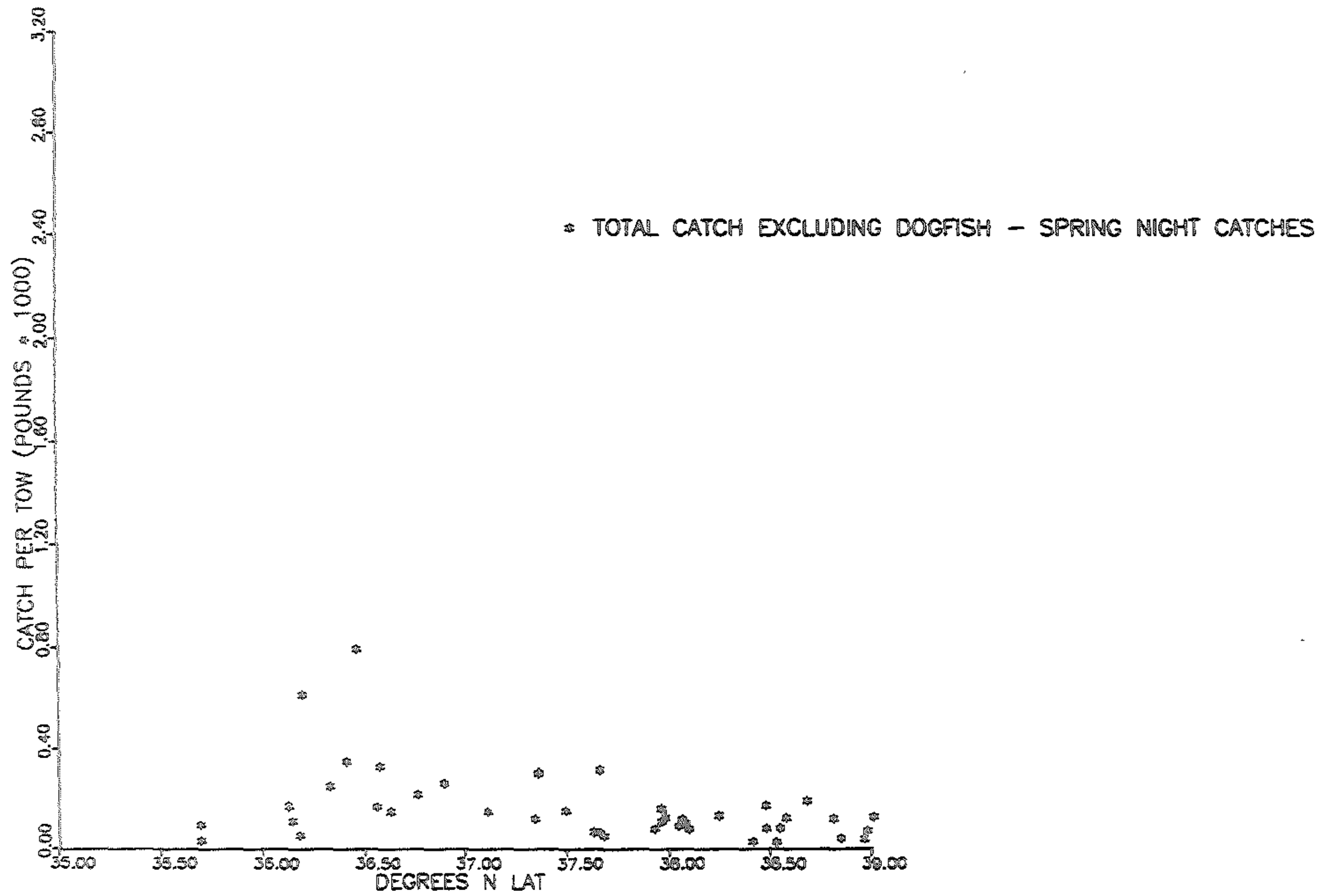
Appendix Figure 2-17. Total catch (excluding spiny dogfish) by latitude for fall day stations.



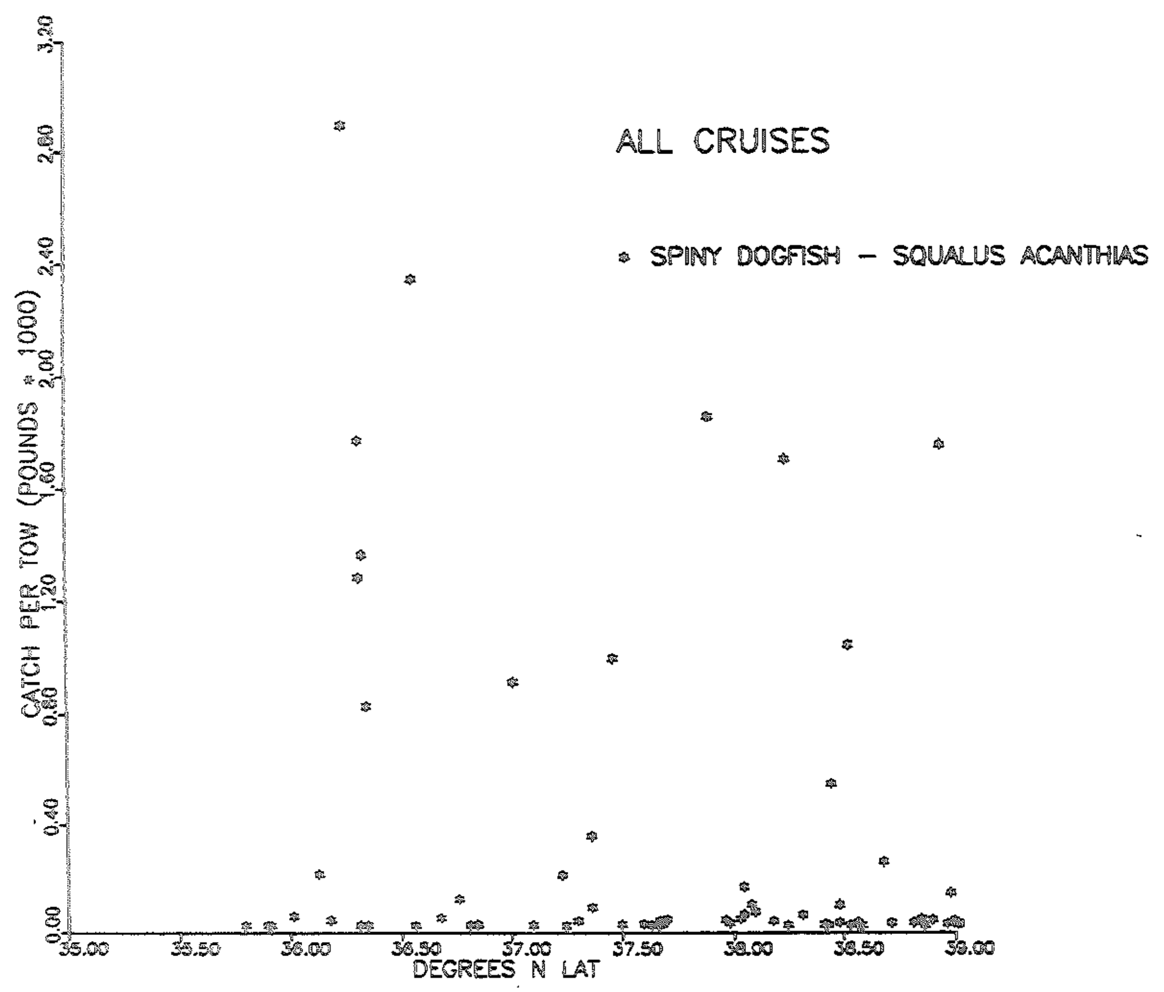
2-18. Total catch (excluding spiny dogfish) by latitude for fall night stations.



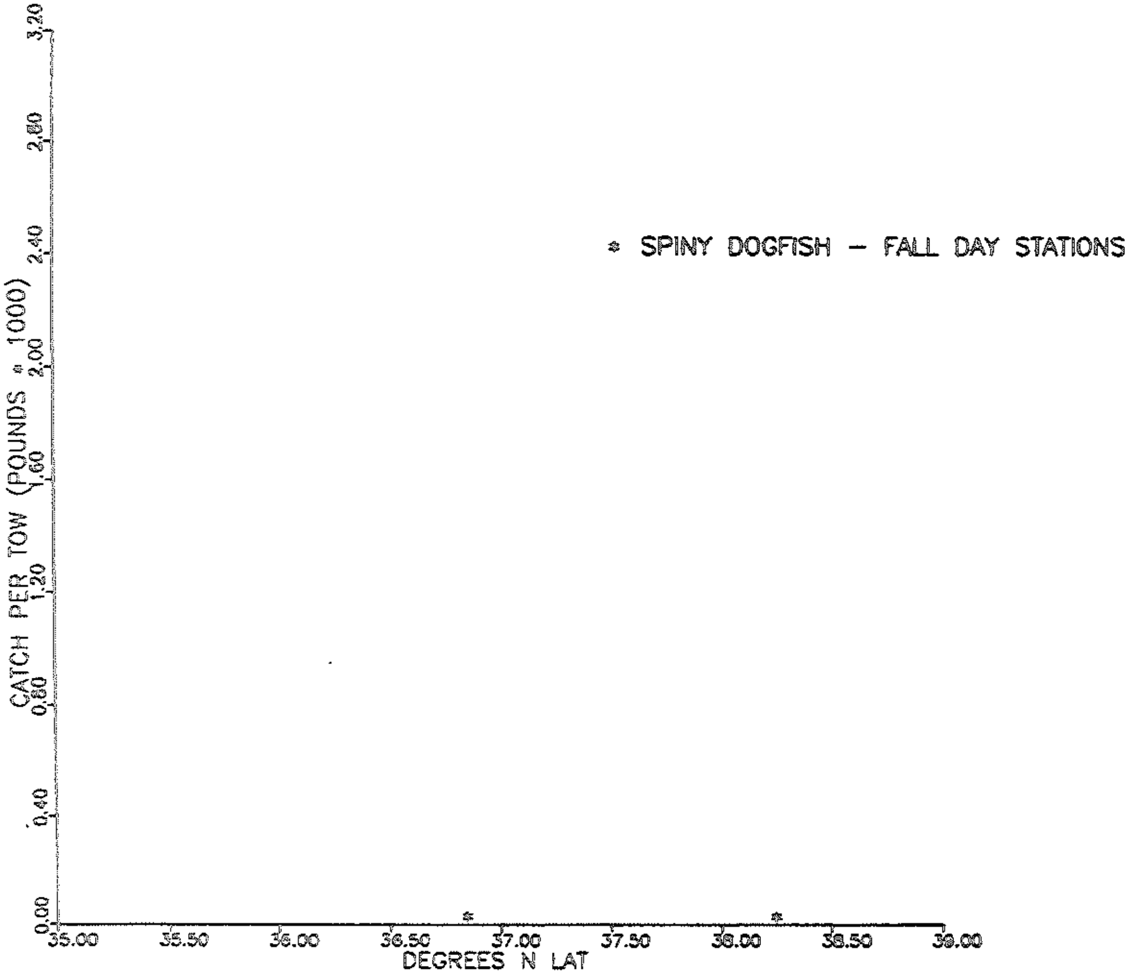
Appendix Figure 2-19. Total catch (excluding spiny dogfish) by latitude for spring day stations.



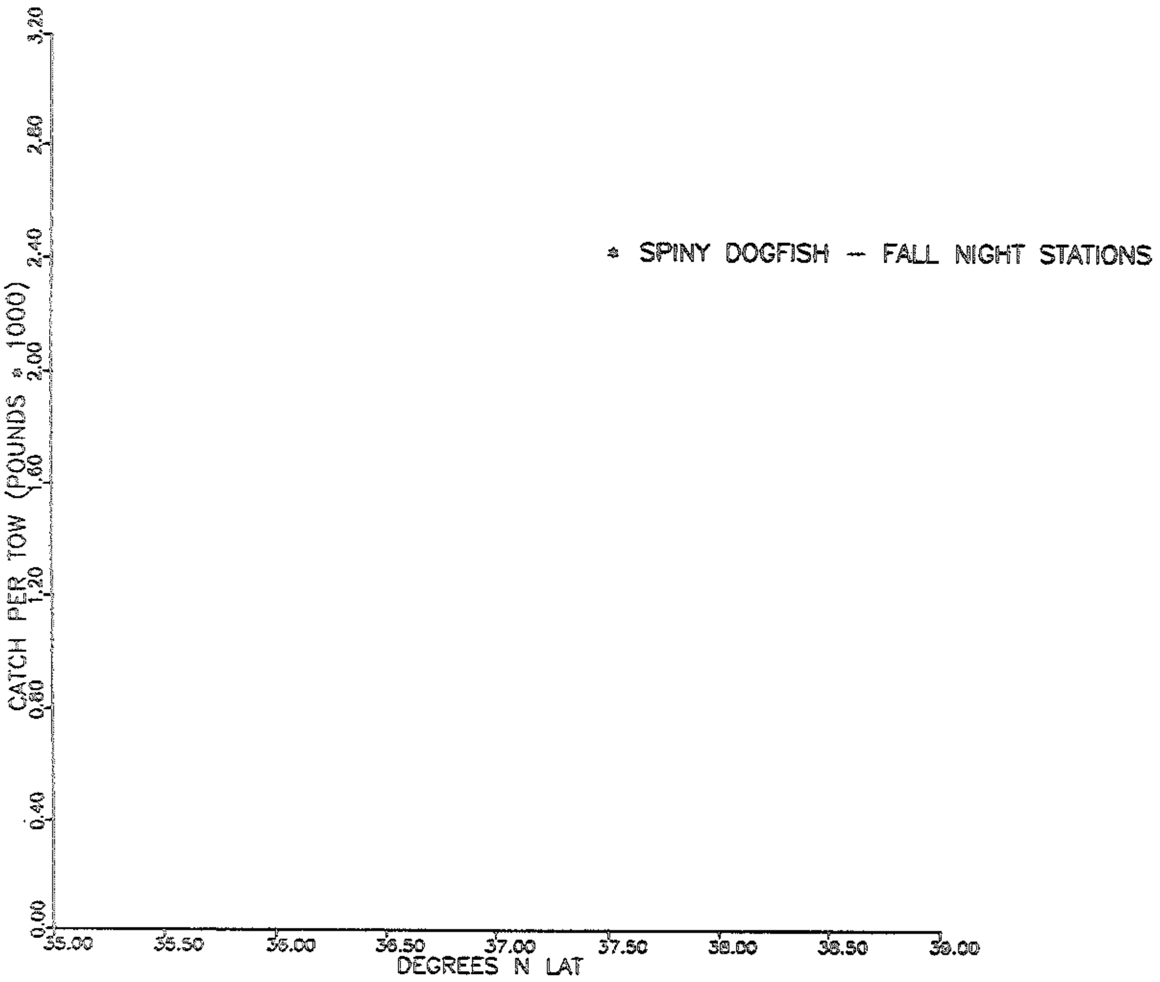
Appendix Figure 2-20. Total catch (excluding spiny dogfish) by latitude for spring night stations.



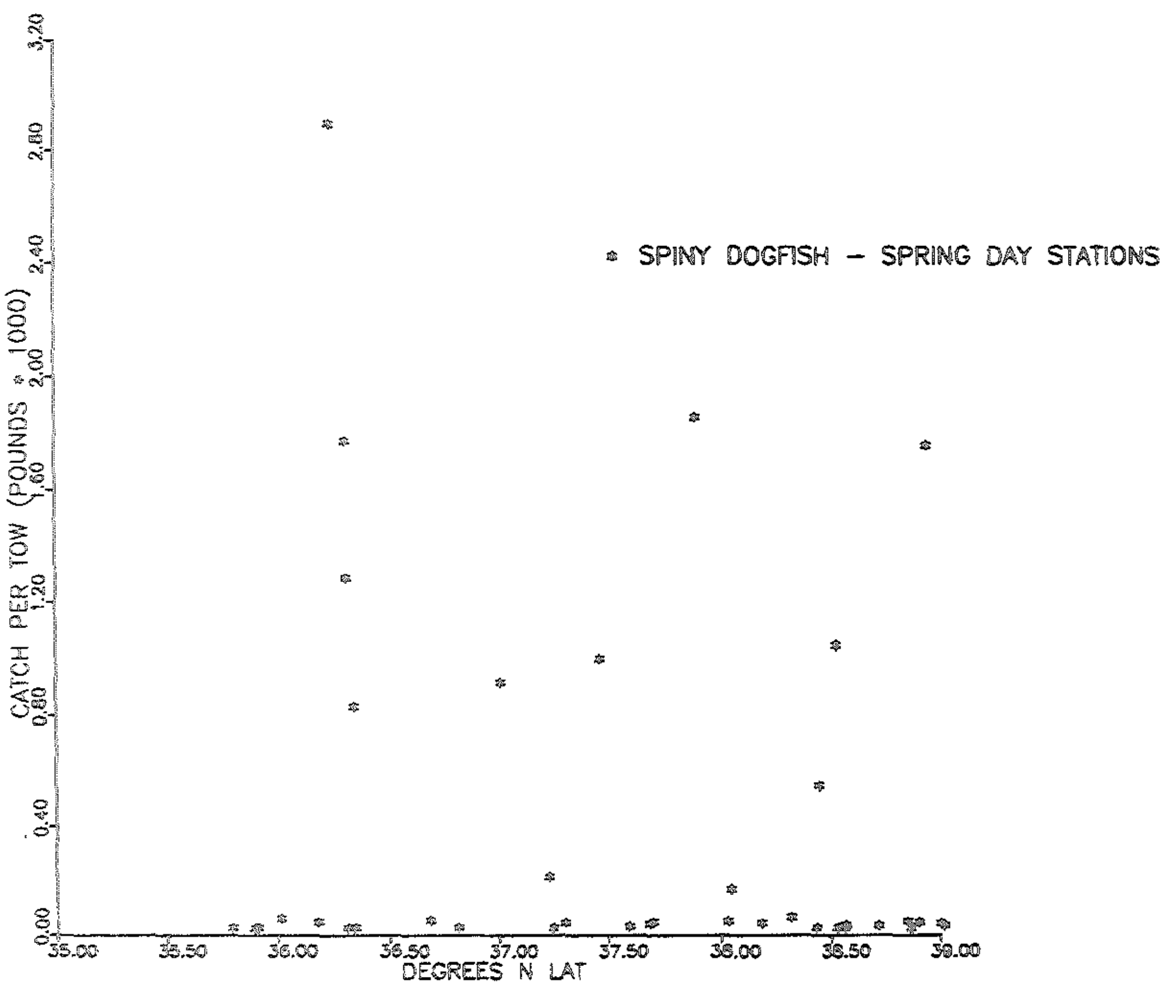
Appendix Figure 2-21. Catch by latitude of spiny dogfish for all cruises.



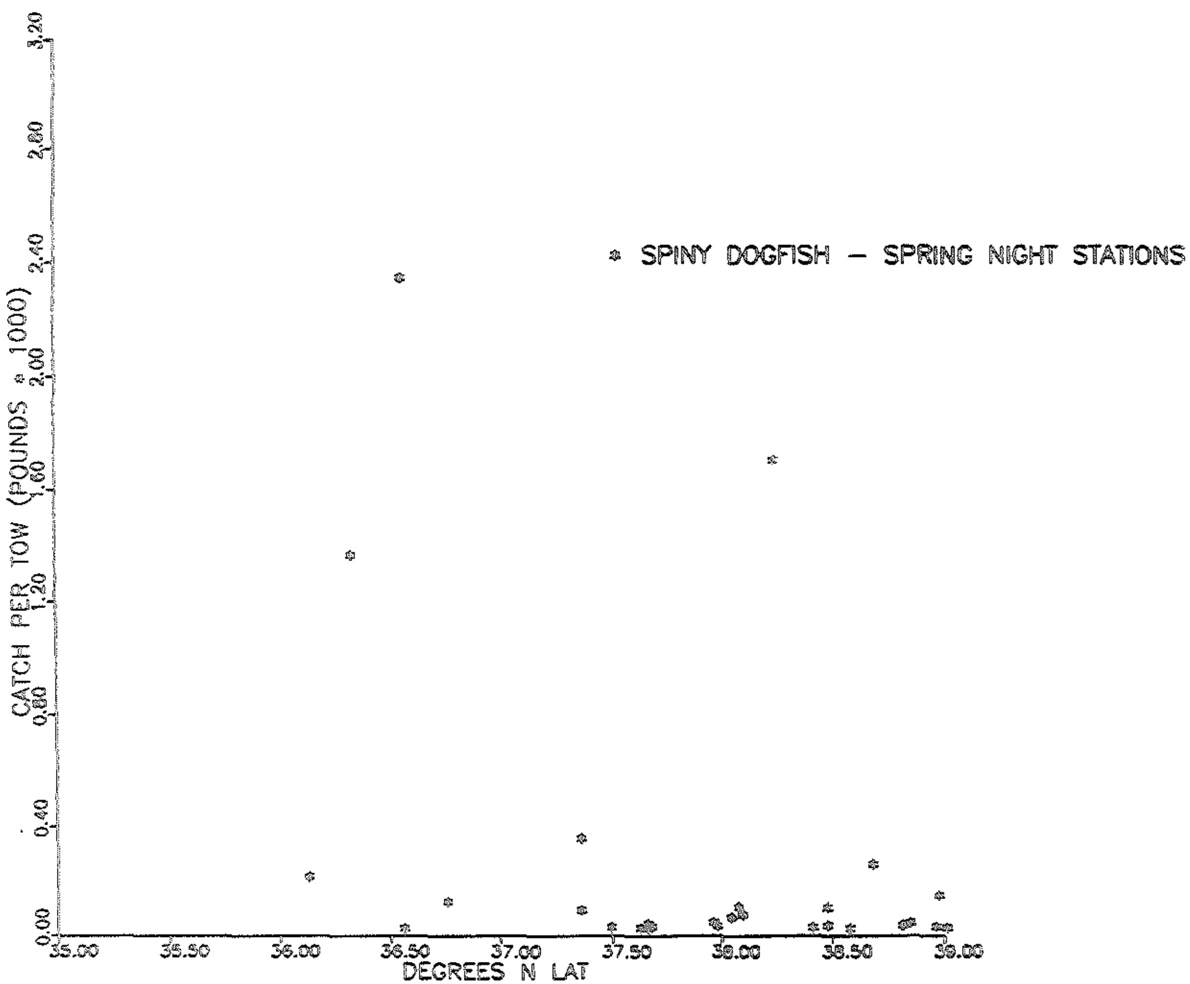
Appendix Figure 2-22. Catch by latitude of spiny dogfish for fall day stations.



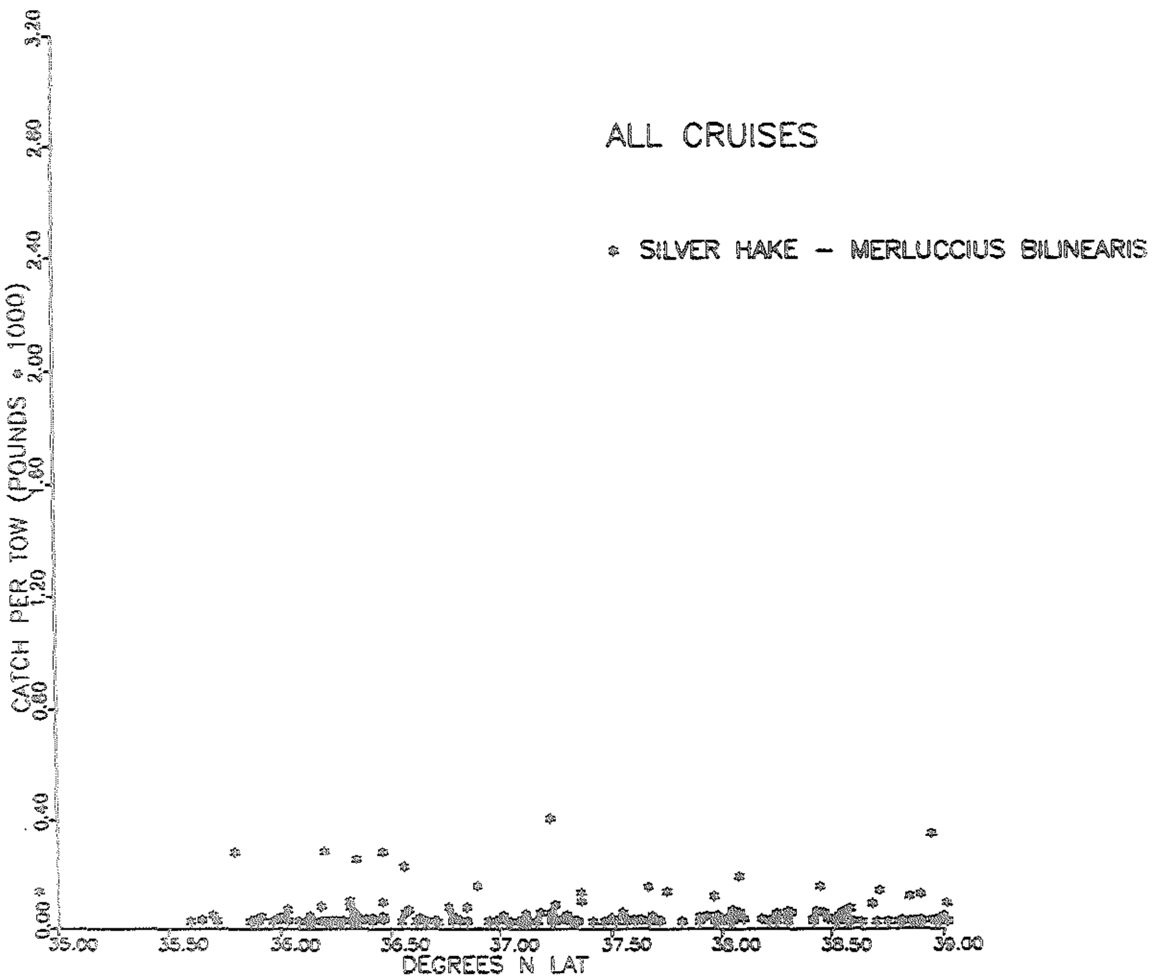
Appendix Figure 2-23. Catch by latitude of spiny dogfish for fall night stations.



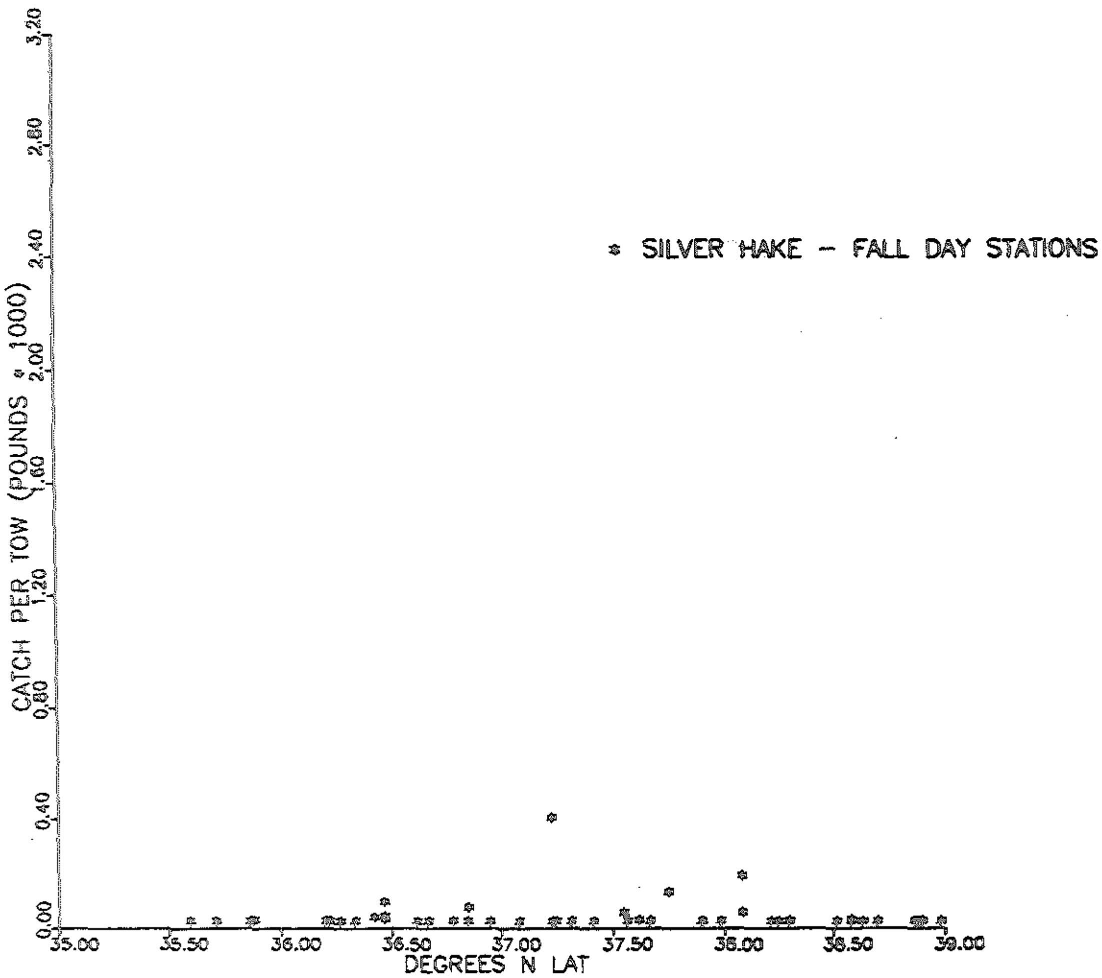
Appendix Figure 2-24. Catch by latitude of spiny dogfish for spring day stations.



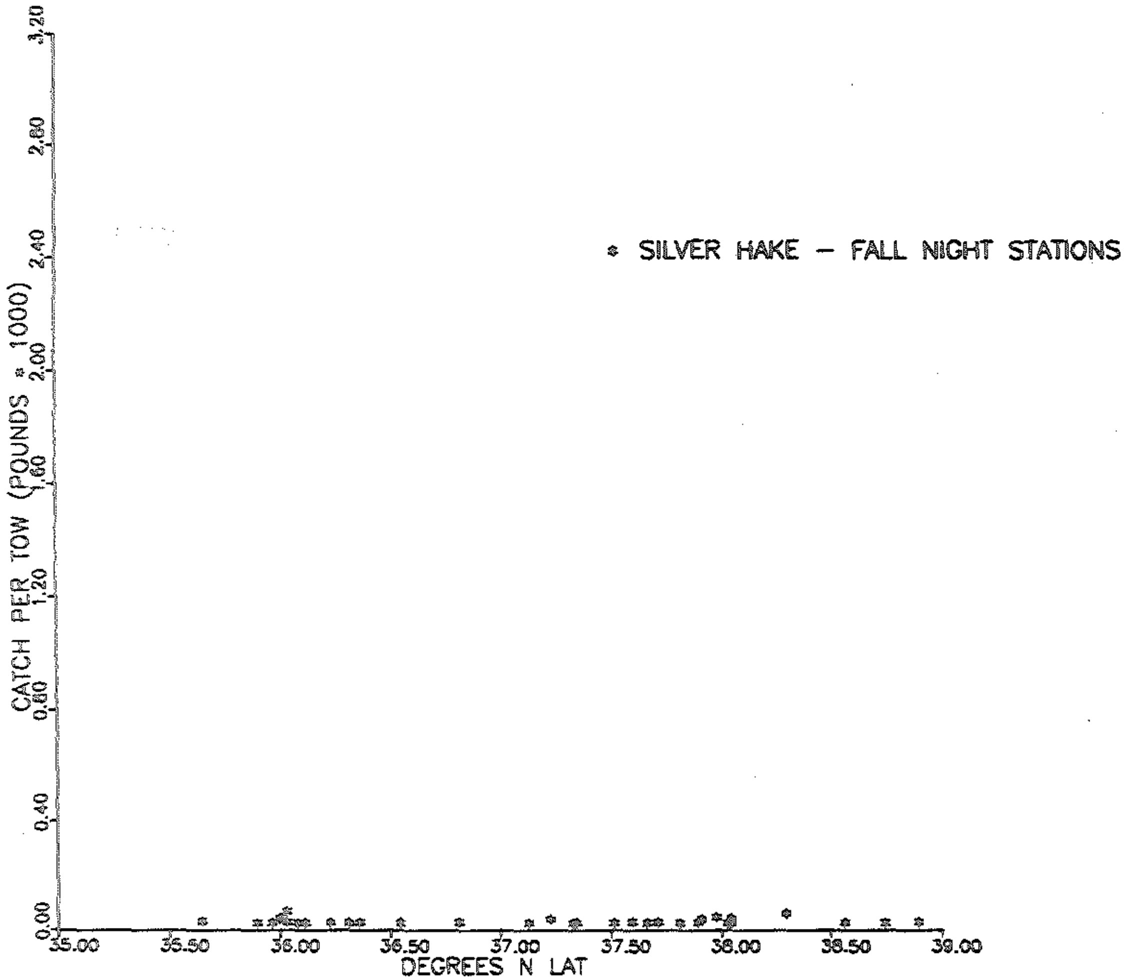
Appendix Figure 2-25. Catch by latitude of spiny dogfish for spring night stations.



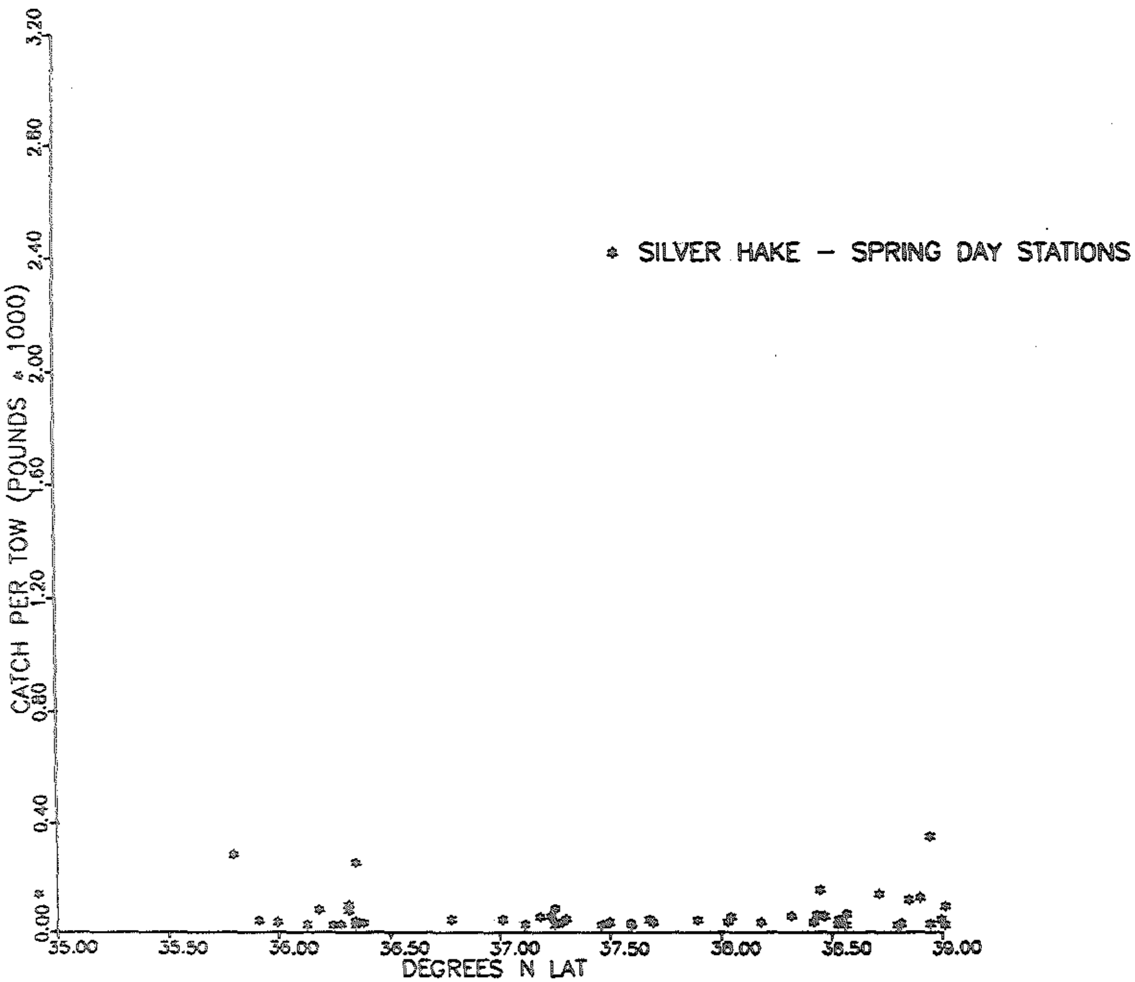
Appendix Figure 2-26. Catch by latitude of whiting for all cruises.



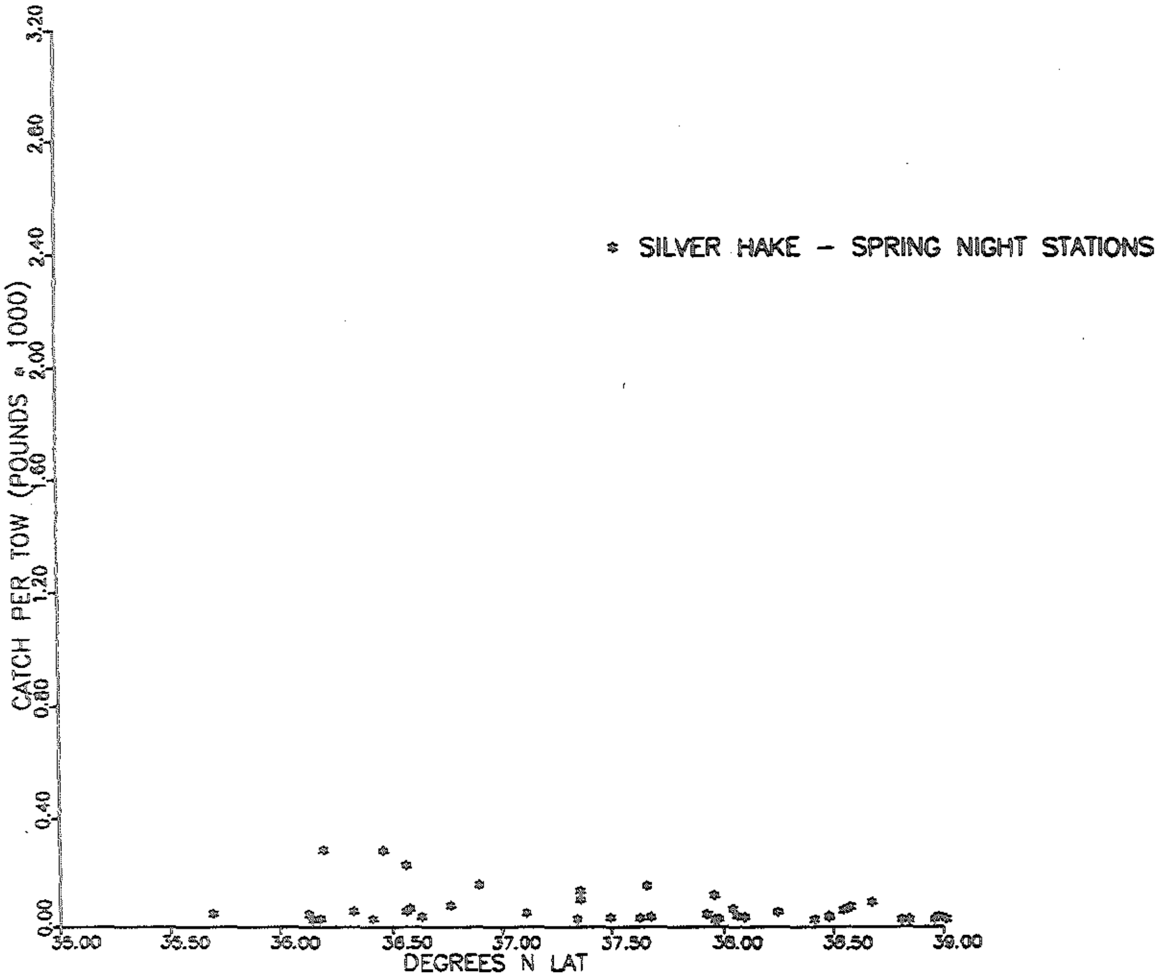
Appendix Figure 2-27. Catch by latitude of whiting for fall day stations.



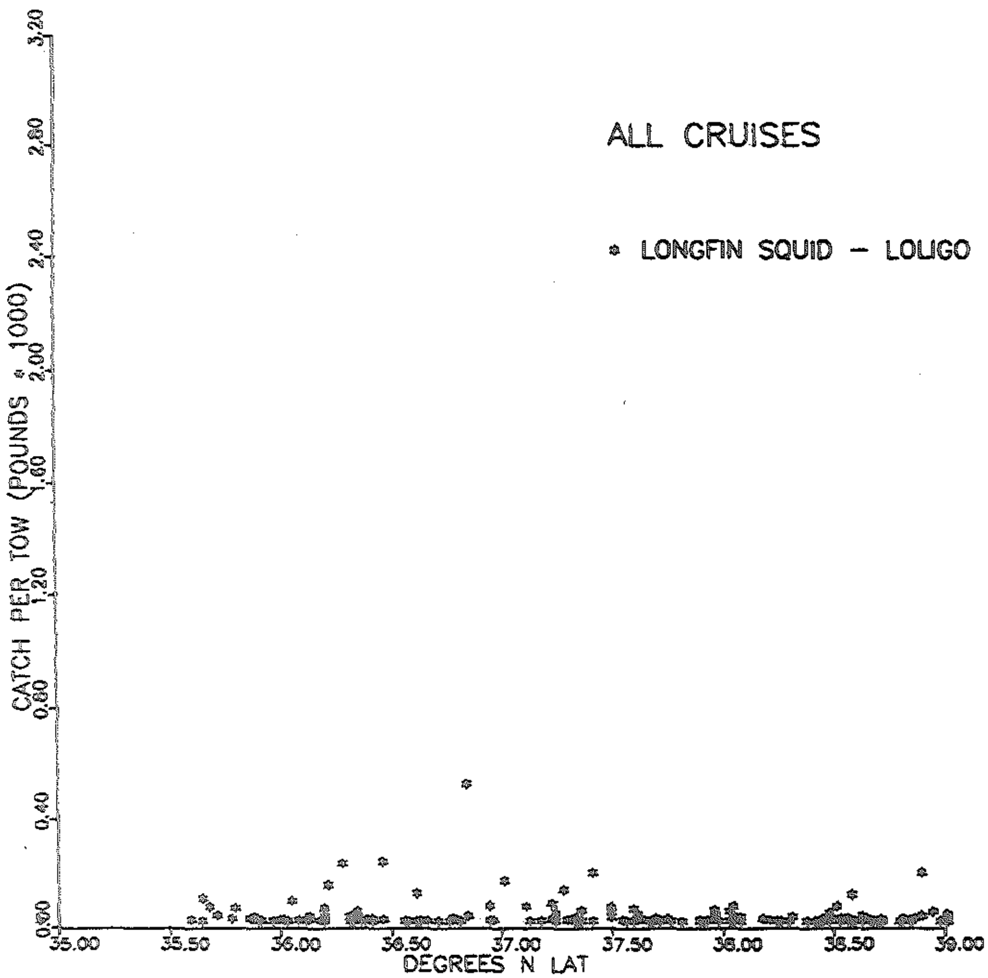
Appendix Figure 2-28. Catch by latitude of whiting for fall night stations.



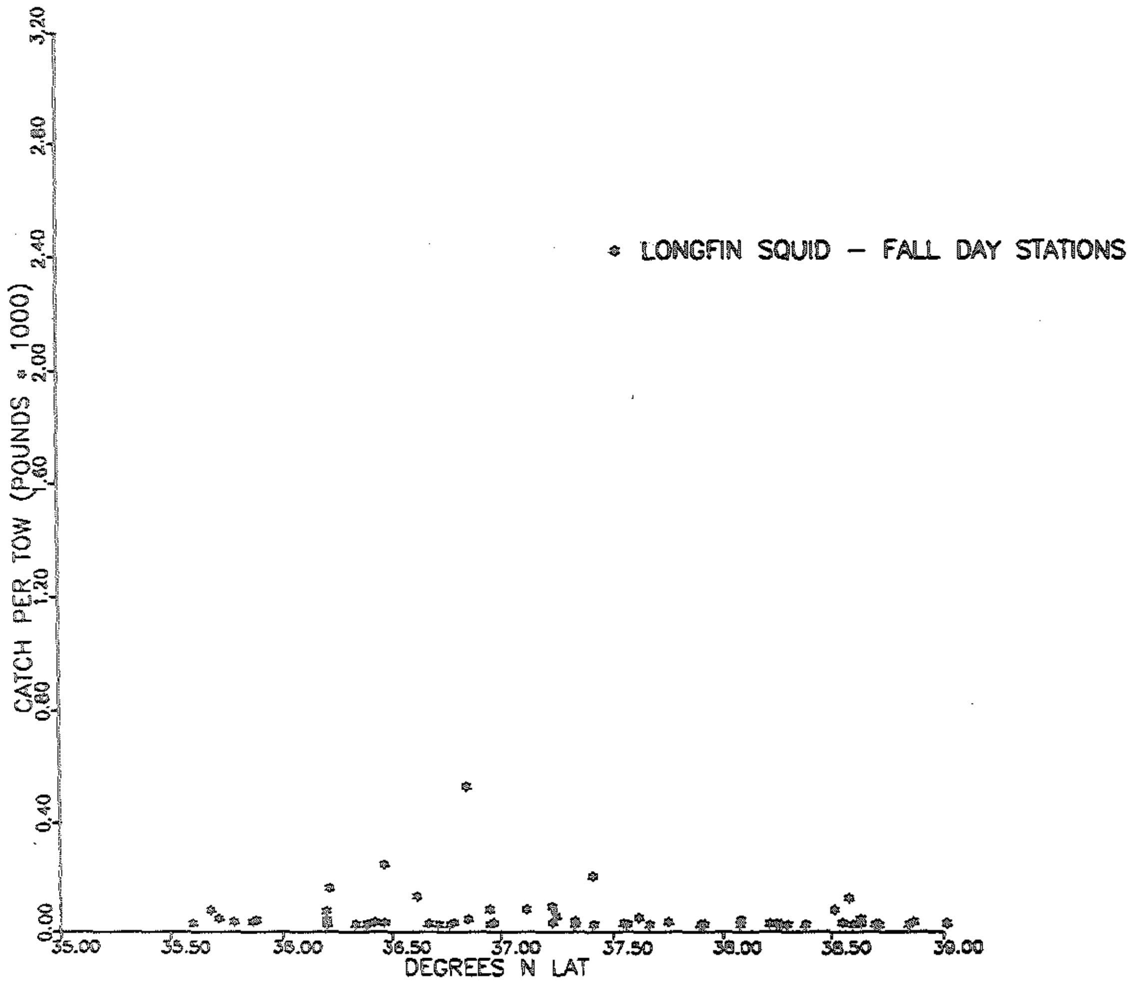
Appendix Figure 2-29. Catch by latitude of whiting for spring day stations.



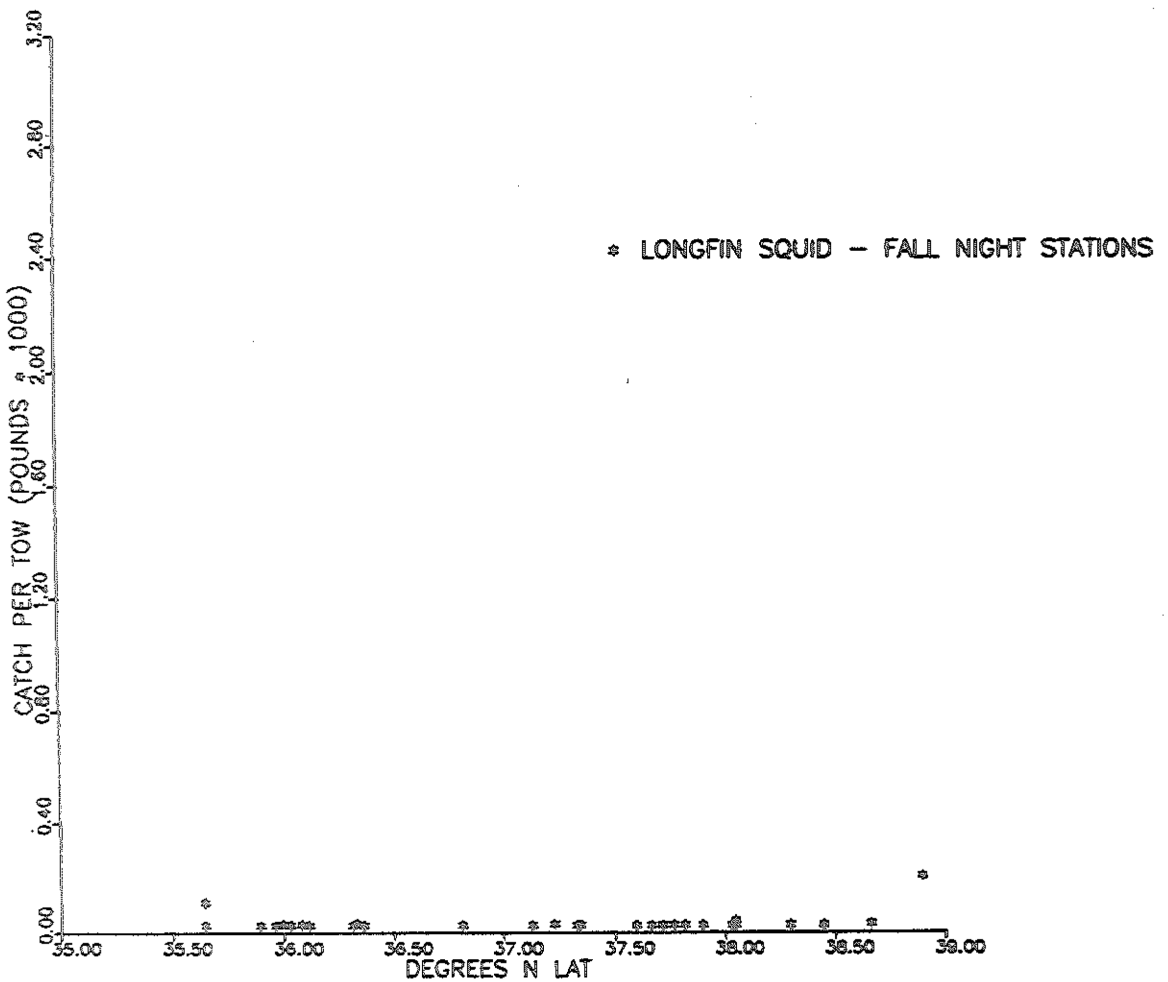
Appendix Figure 2-30. Catch by latitude of whiting for spring night stations.



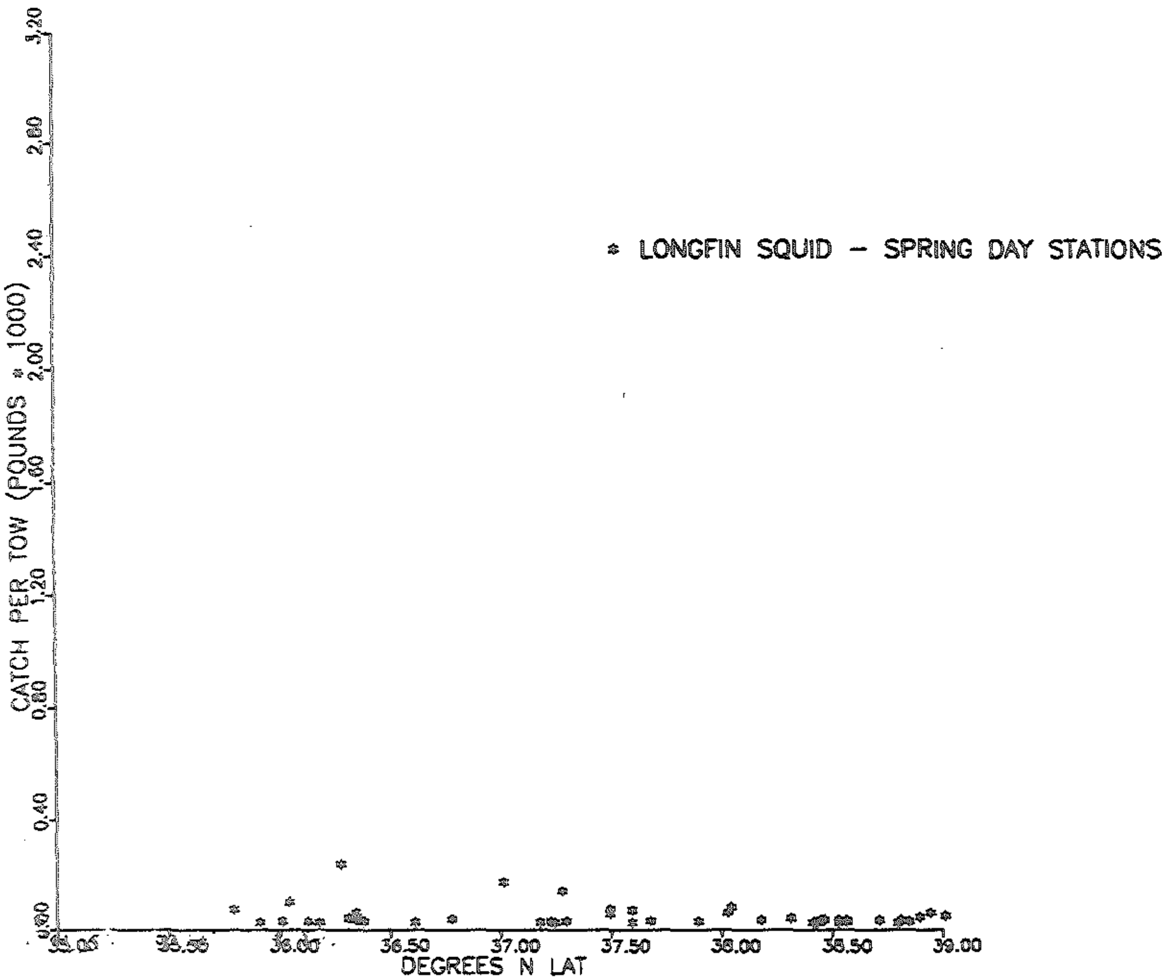
Appendix Figure 2-31. Catch by latitude of longfin squid for all cruises.



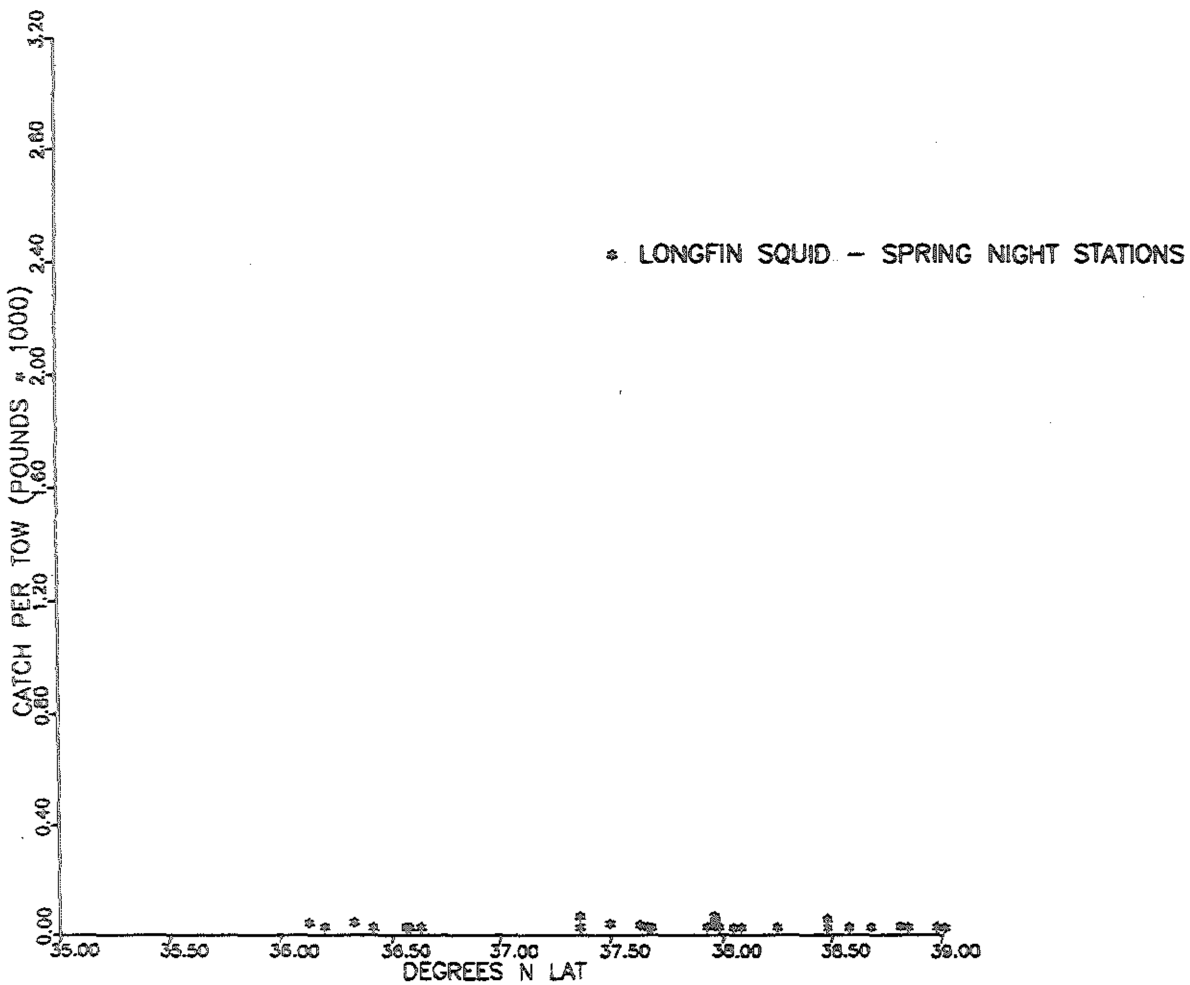
Appendix Figure 2-32. Catch by latitude of longfin squid for fall day stations.



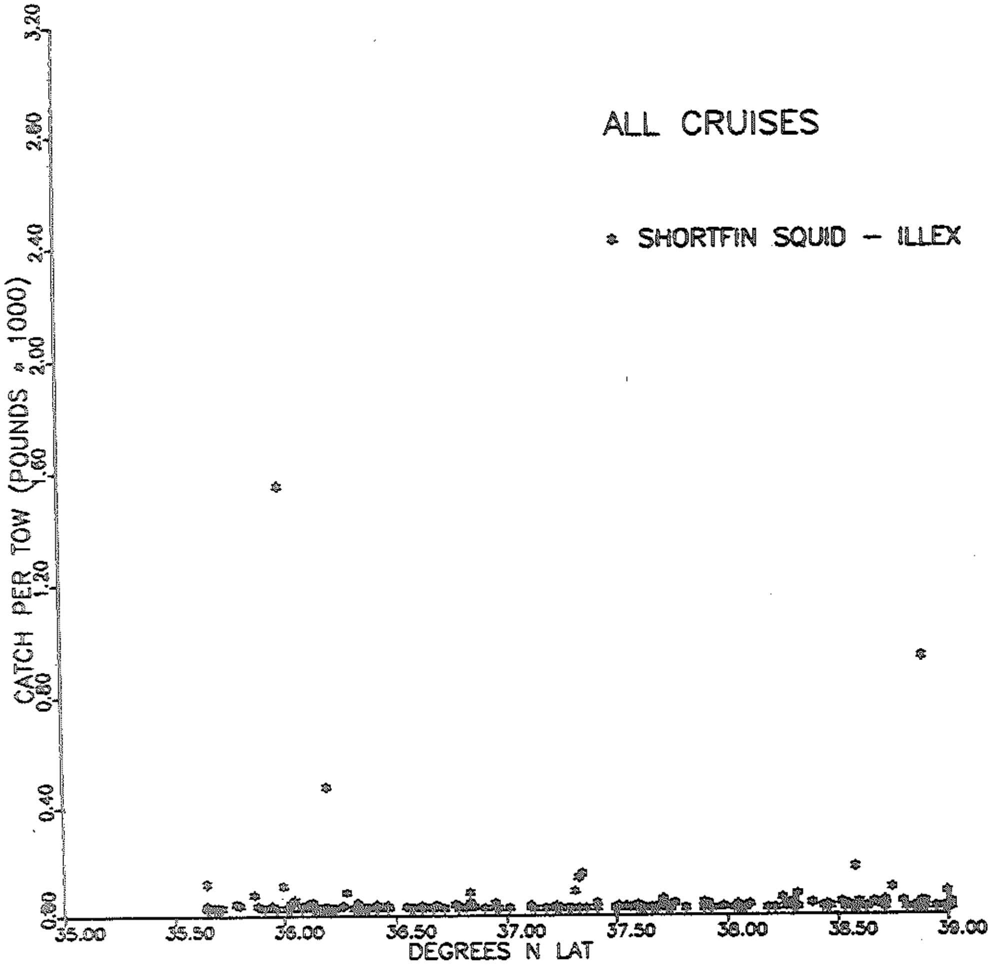
Appendix Figure 2-33. Catch by latitude of longfin squid for fall night stations.



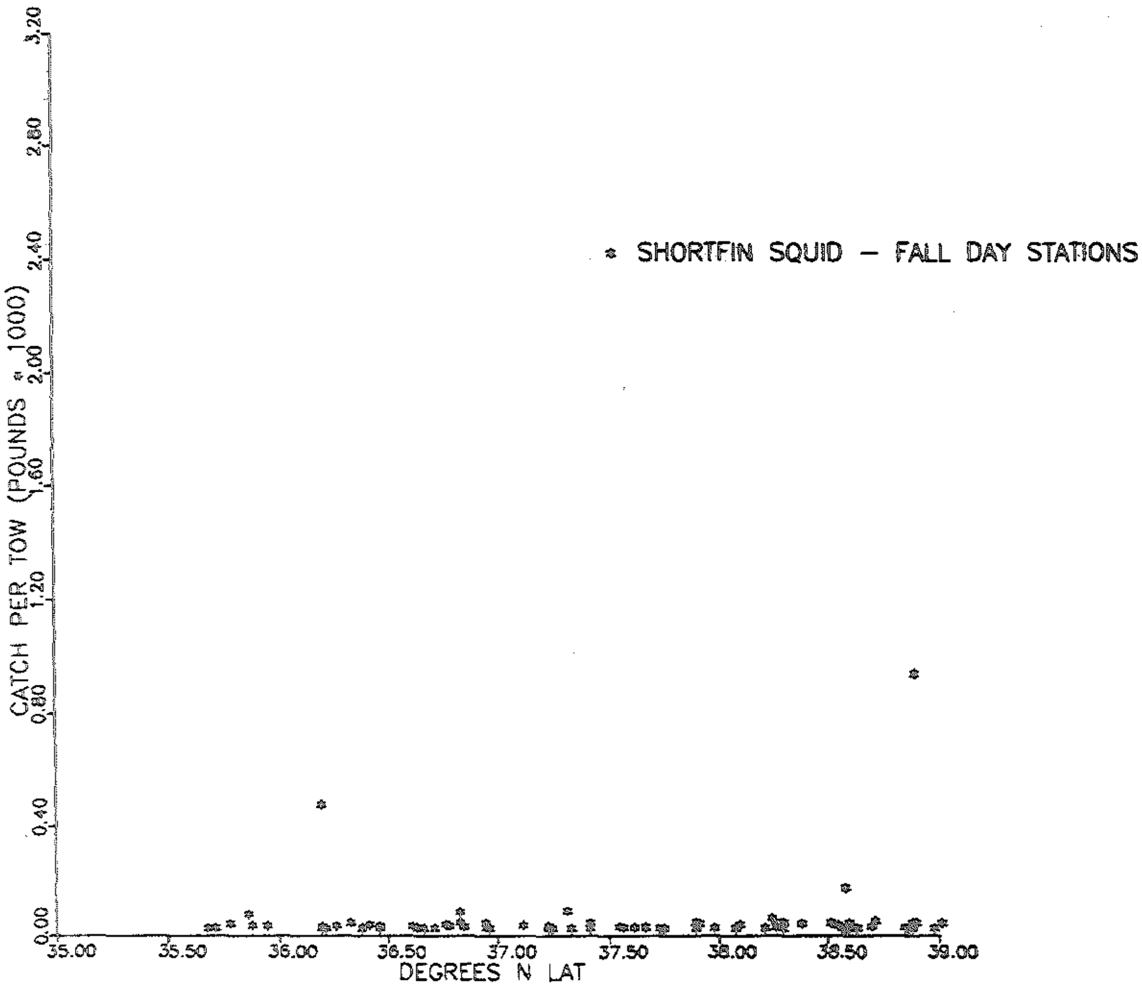
Appendix Figure 2-34. Catch by latitude of longfin squid for spring day stations.



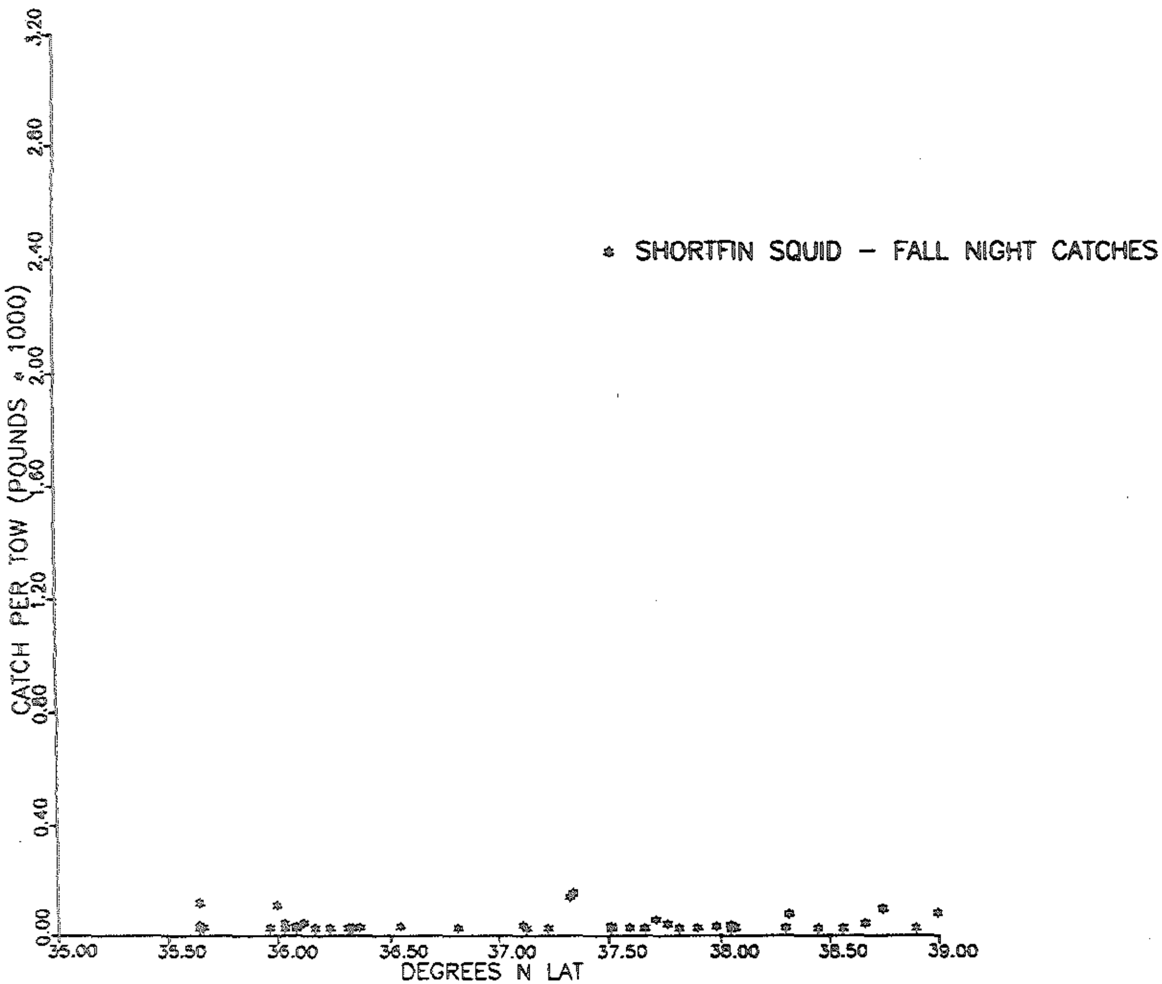
Appendix Figure 2-35. Catch by latitude of longfin squid for spring night stations.



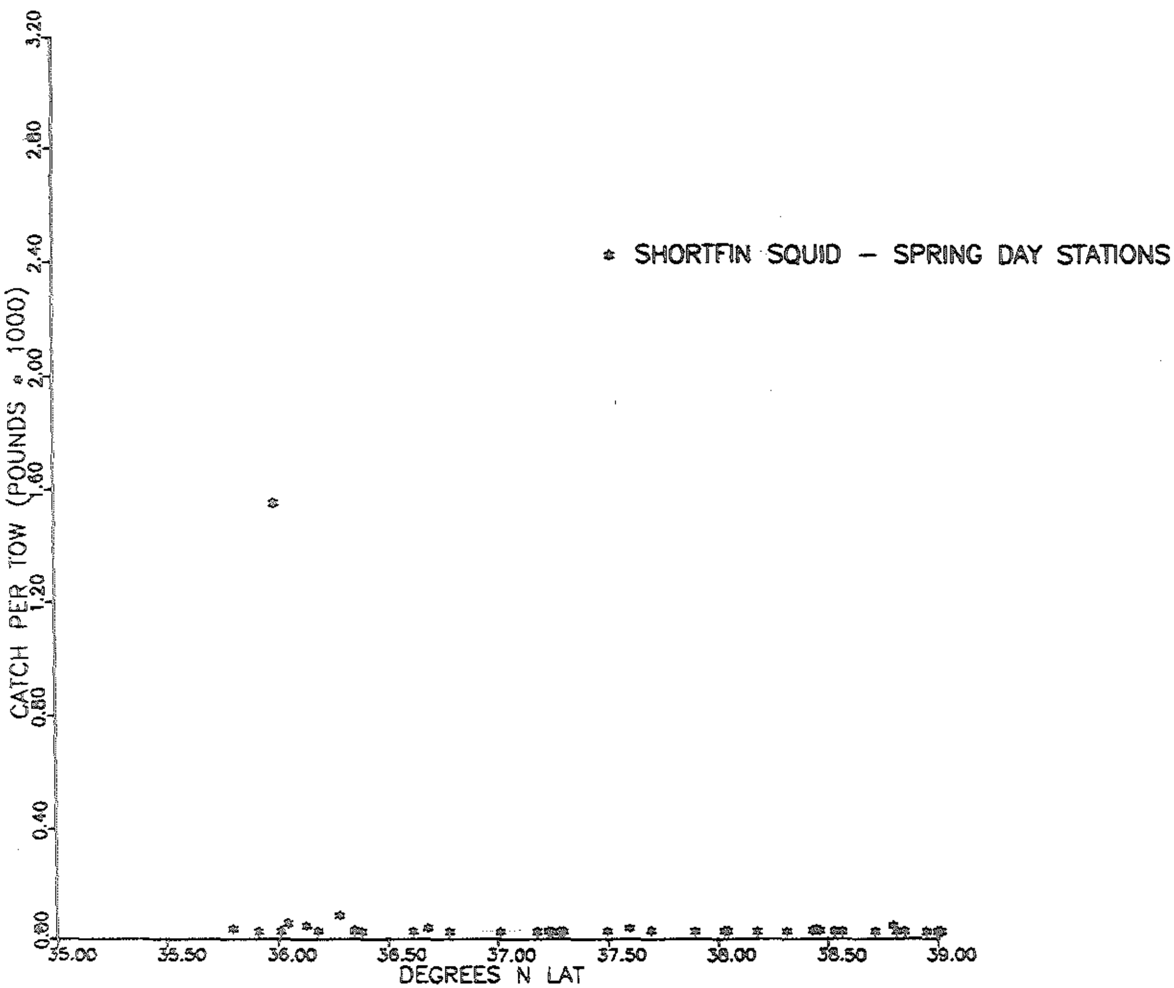
Appendix Figure 2-36. Catch by latitude of shortfin squid for all cruises.



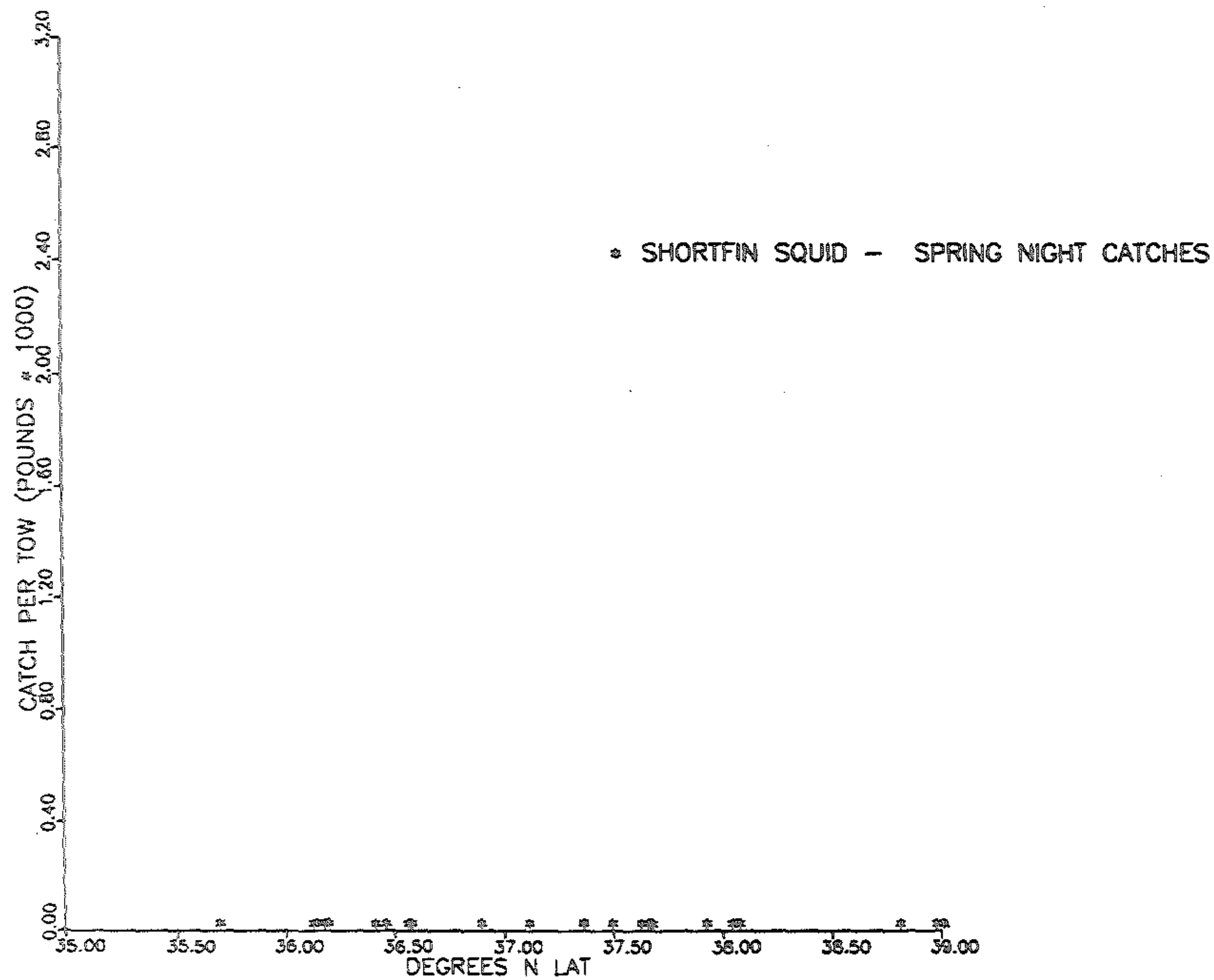
Appendix Figure 2-37. Catch by latitude of shortfin squid for fall day stations.



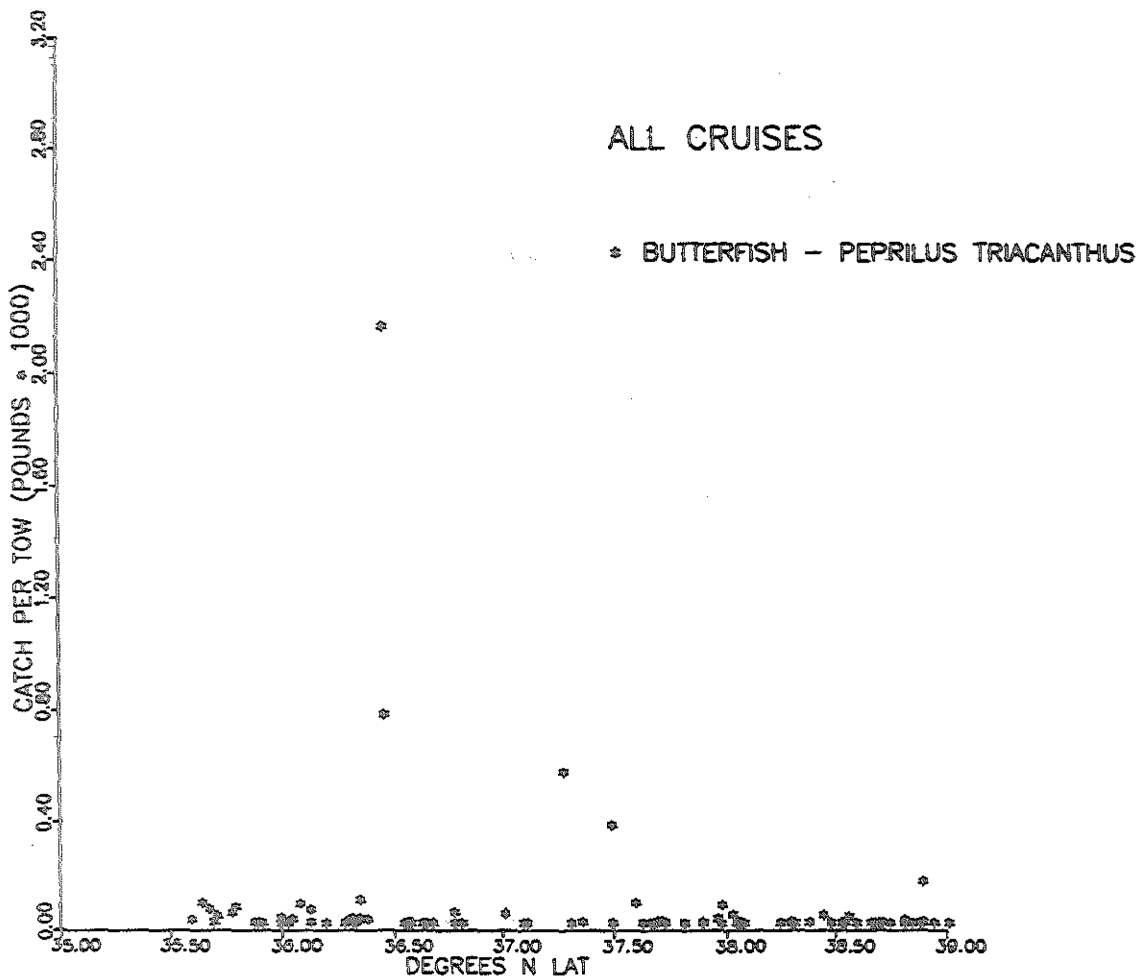
Appendix Figure 2-38. Catch by latitude of shortfin squid for fall night stations.



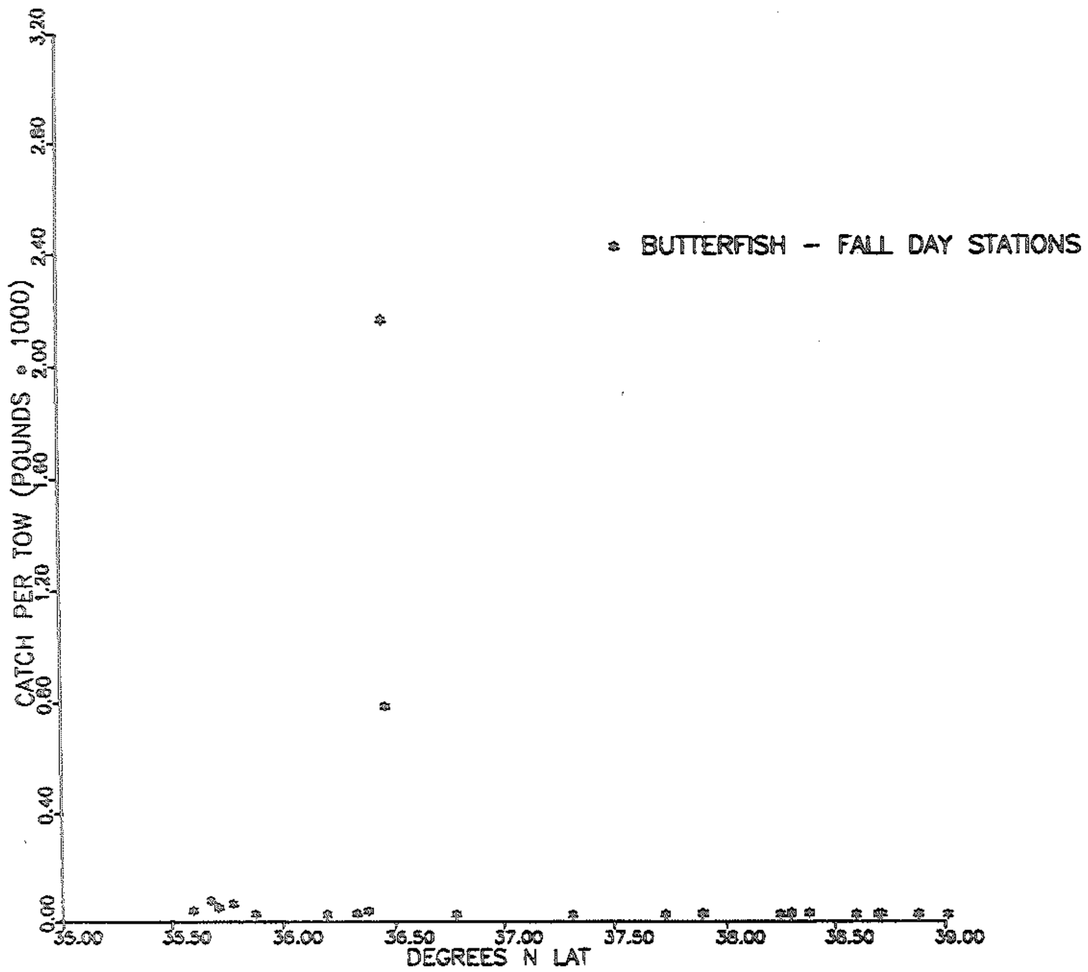
Appendix Figure 2-39. Catch by latitude of shortfin squid for spring day stations.



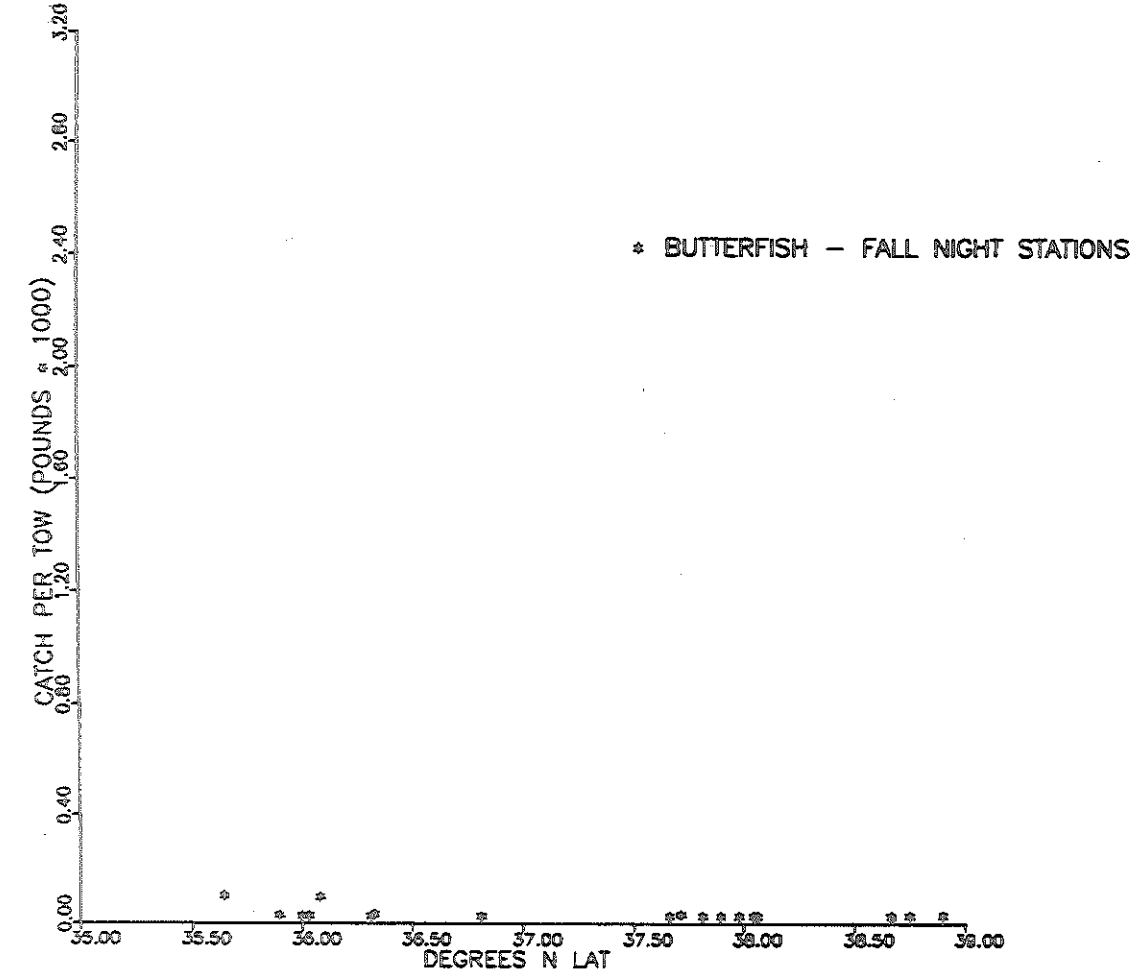
Appendix Figure 2-40. Catch by latitude of shortfin squid for spring night stations.



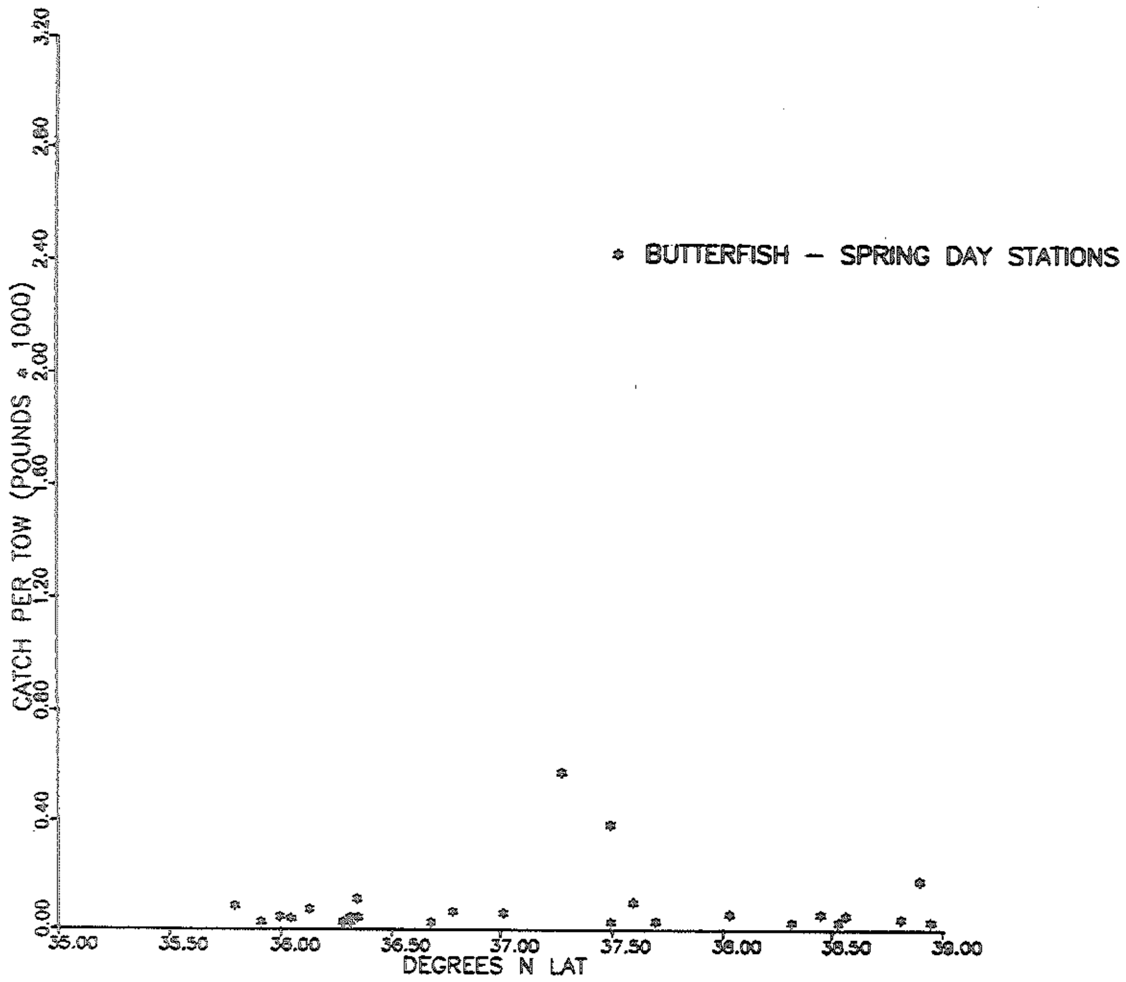
Appendix Figure 2-41. Catch by latitude of butterfish for all cruises.



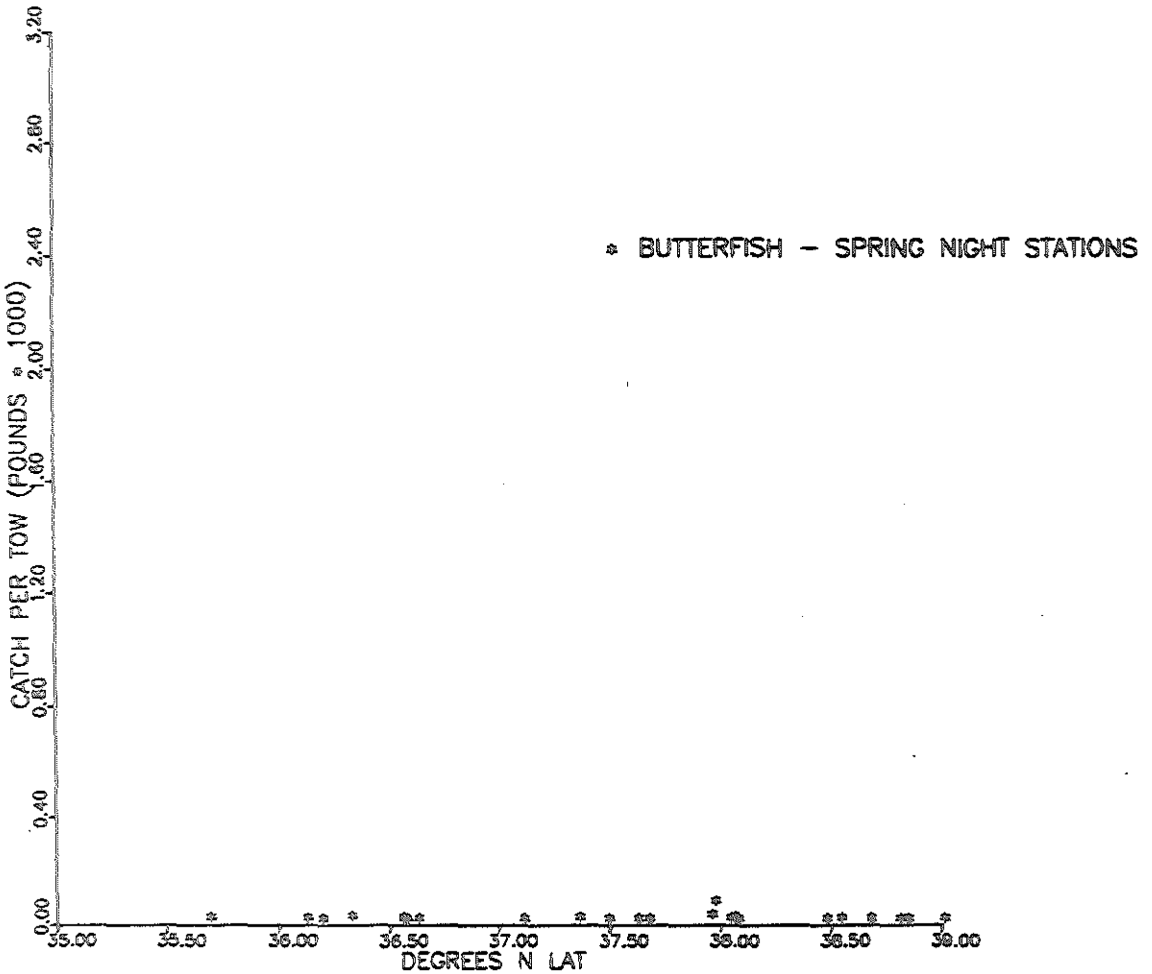
Appendix Figure 2-42. Catch by latitude of butterfish for fall day stations.



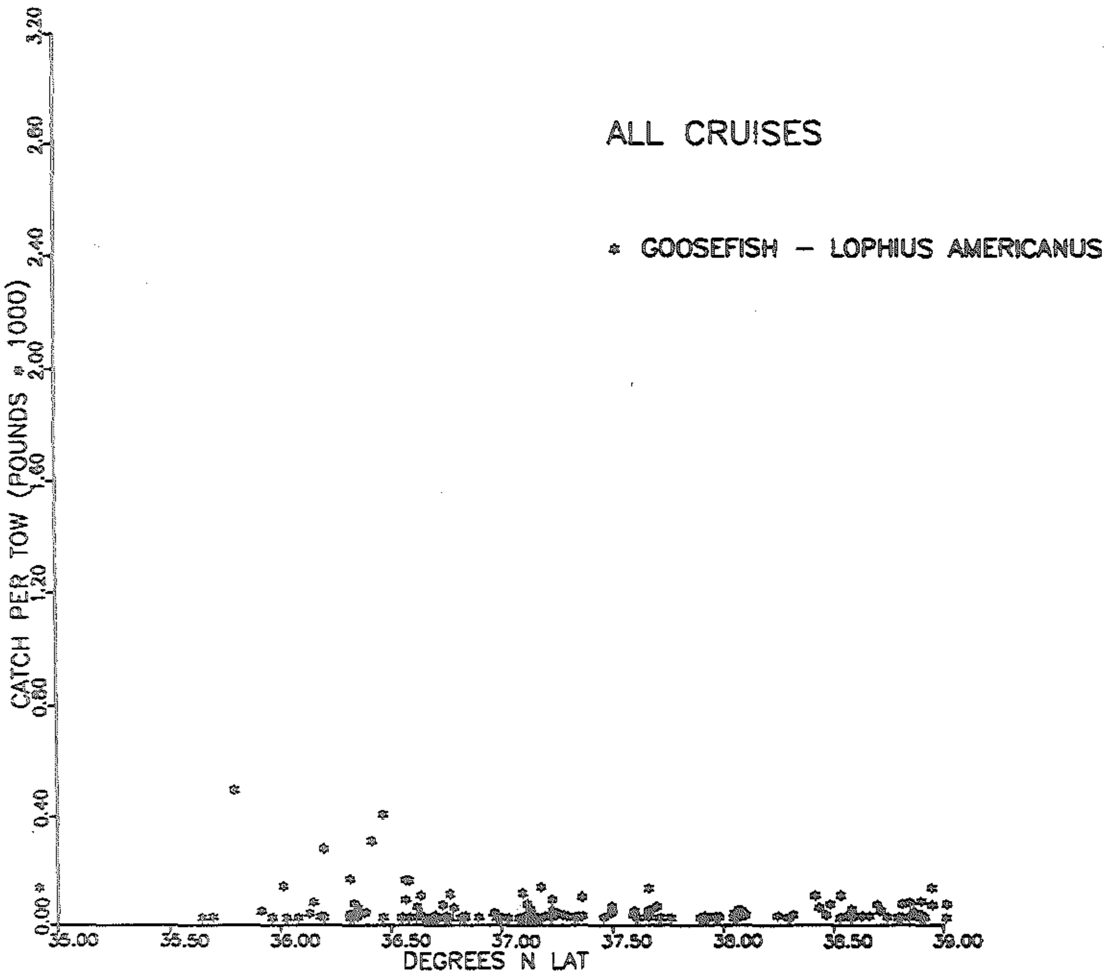
Appendix Figure 2-43. Catch by latitude of butterfish for fall night stations.



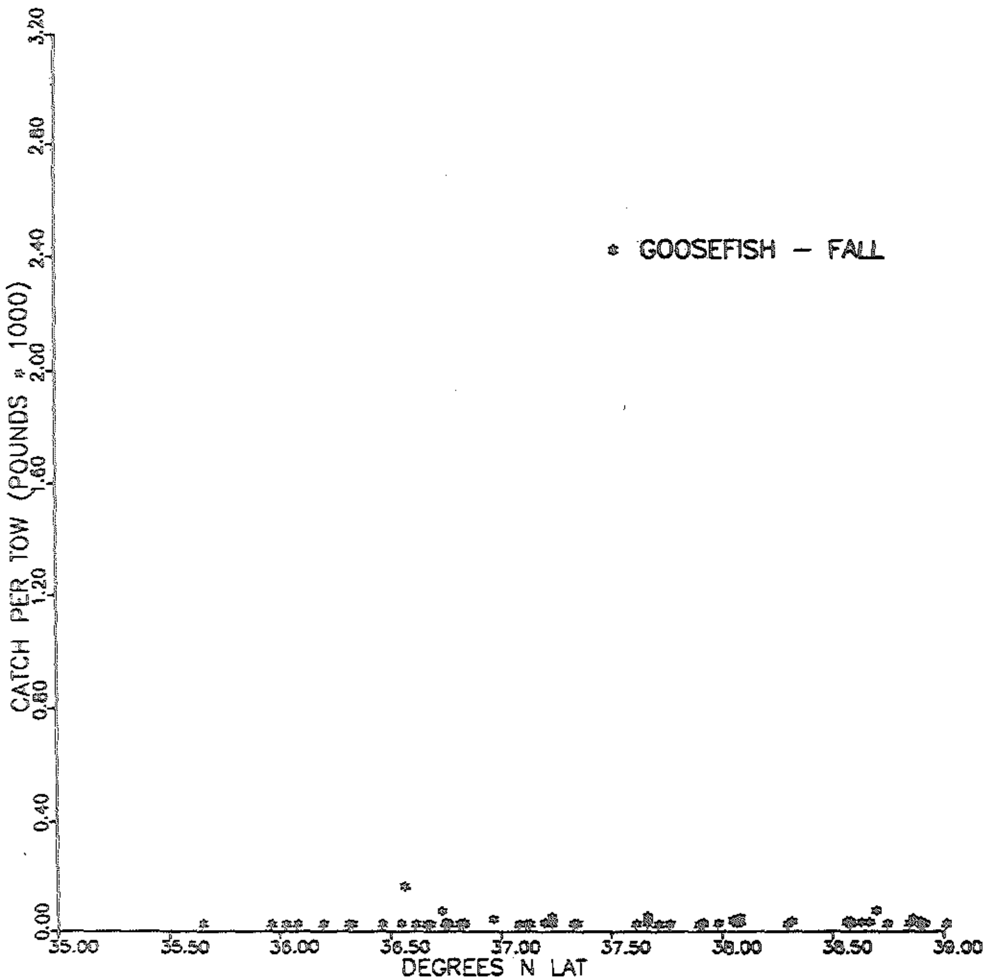
Appendix Figure 2-44. Catch by latitude of butterfish for spring day stations.



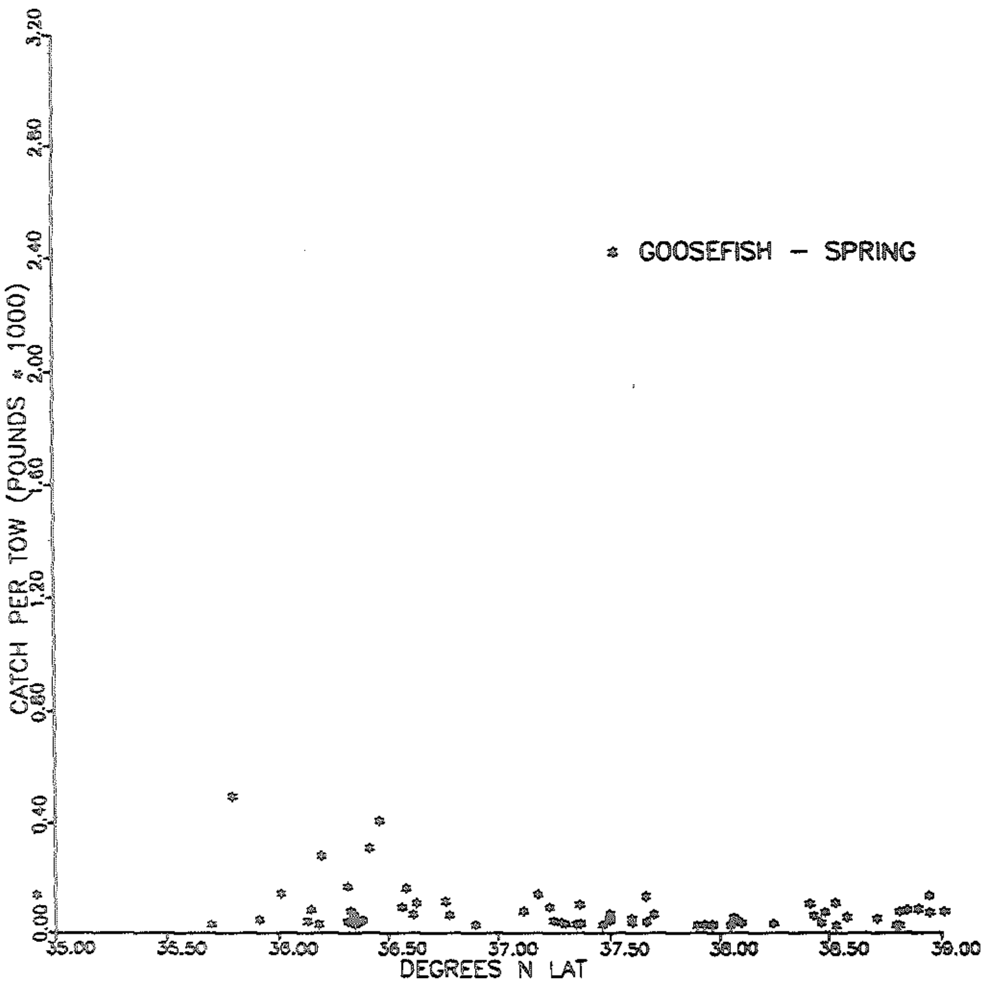
Appendix Figure 2-45. Catch by latitude of butterfish for spring night stations.



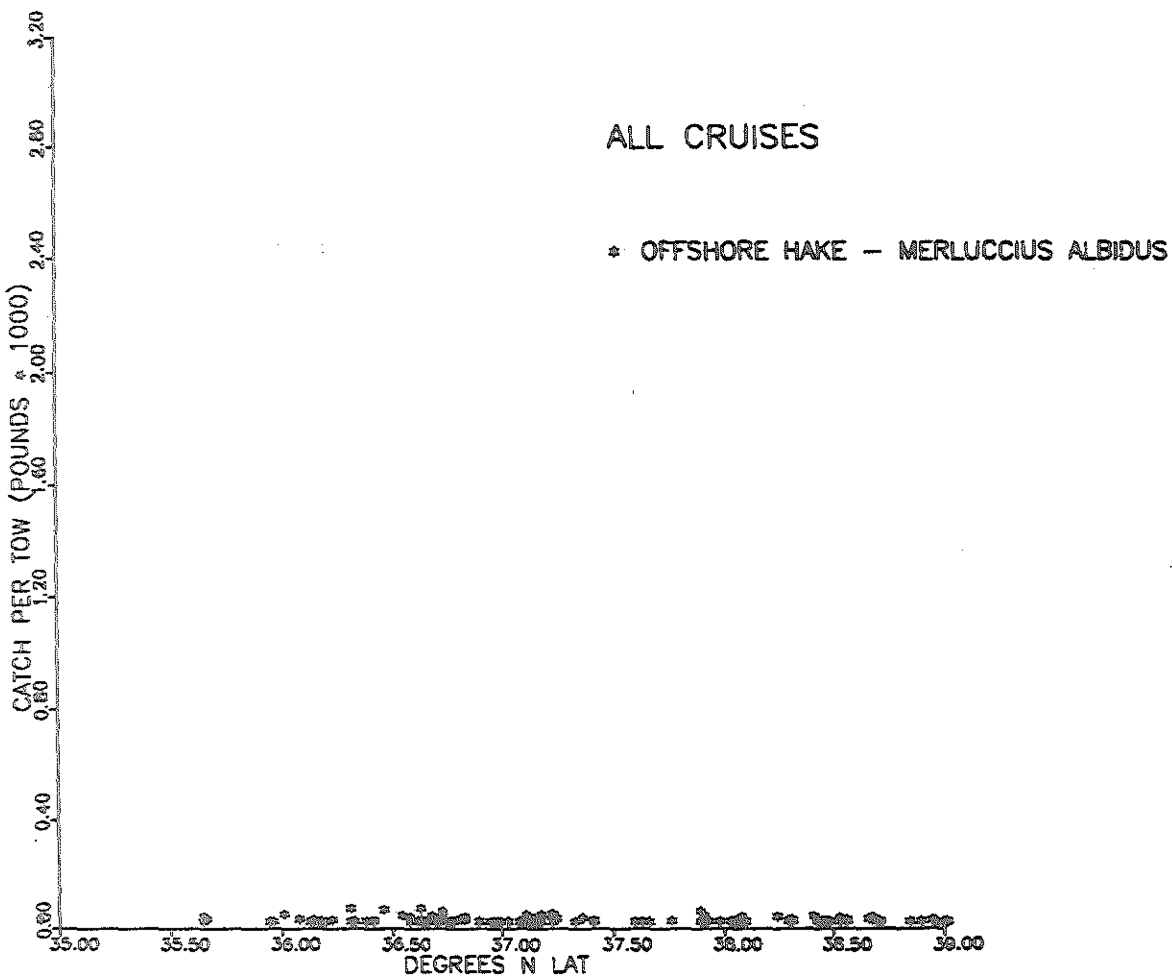
Appendix Figure 2-46. Catch by latitude of monkfish for all cruises.



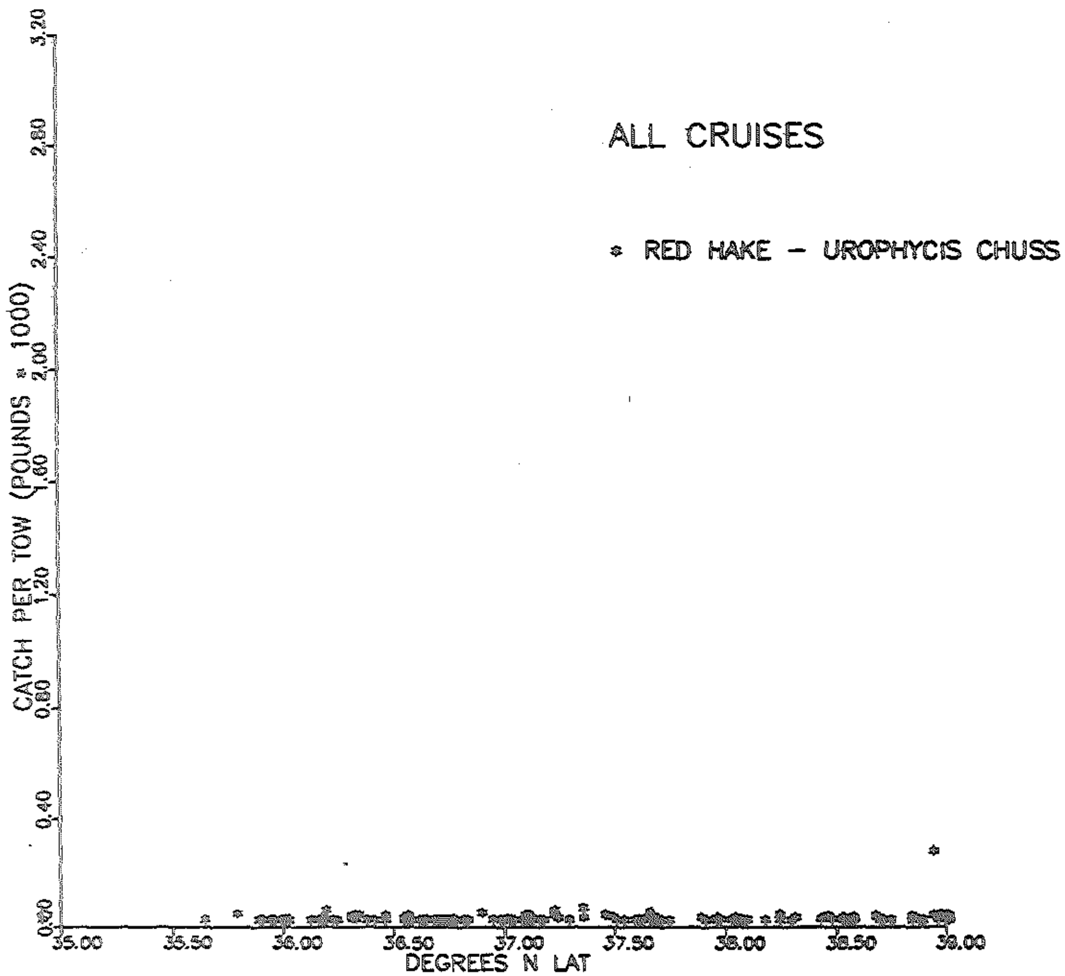
Appendix Figure 2-47. Catch by latitude of monkfish for fall cruises.



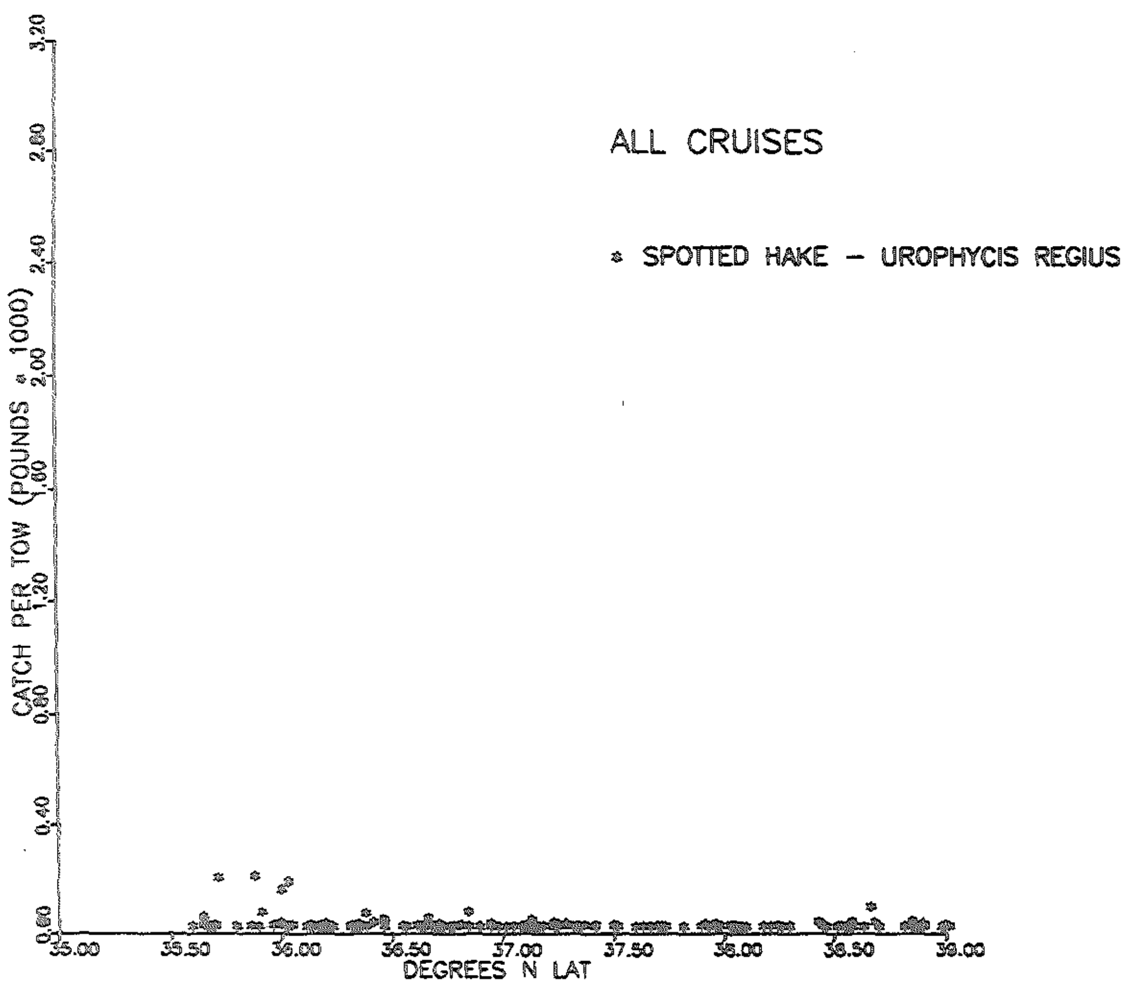
Appendix Figure 2-48. Catch by latitude of monkfish for spring cruises.



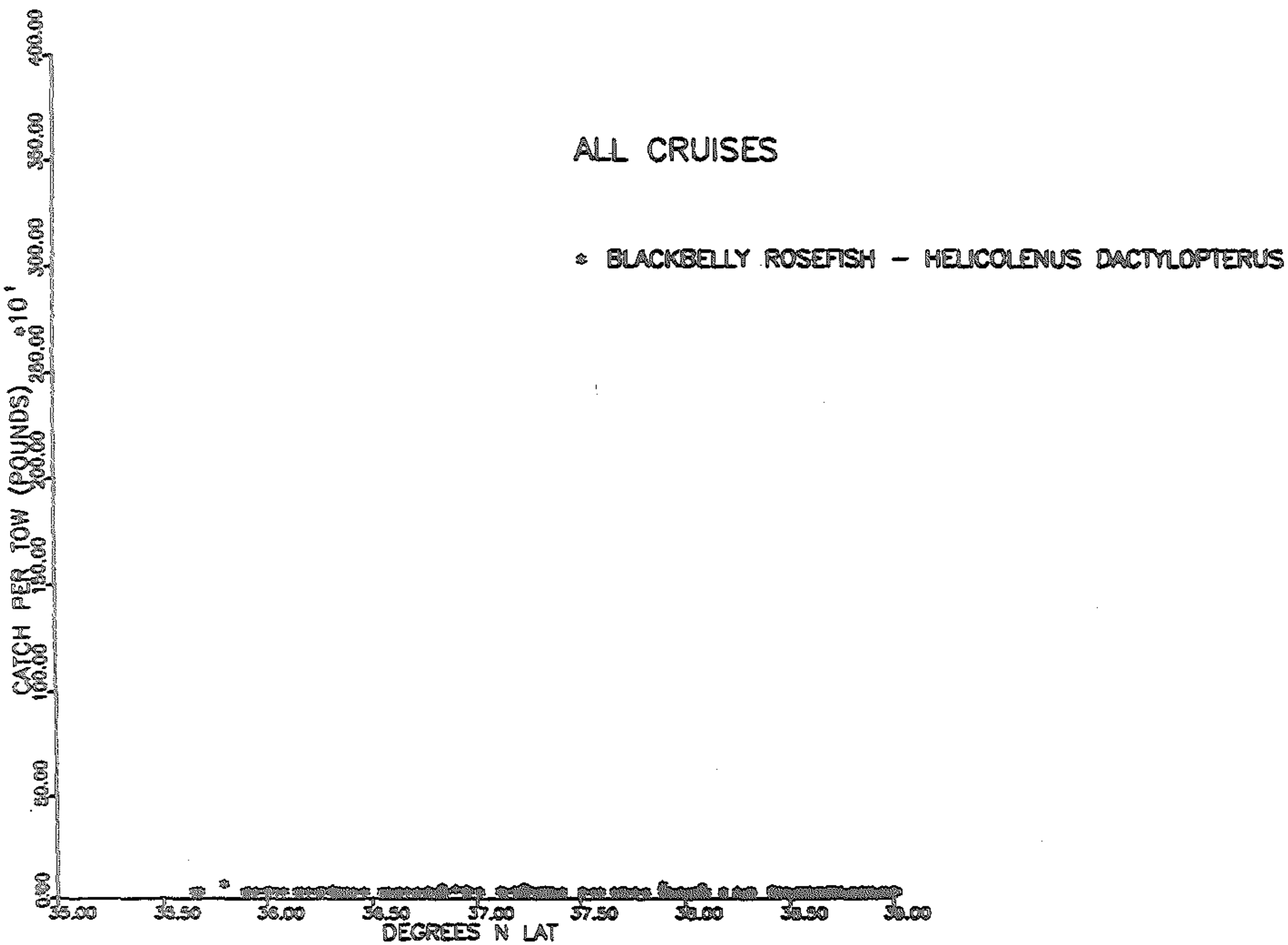
Appendix Figure 2-49. Catch by latitude of offshore hake for all cruises.



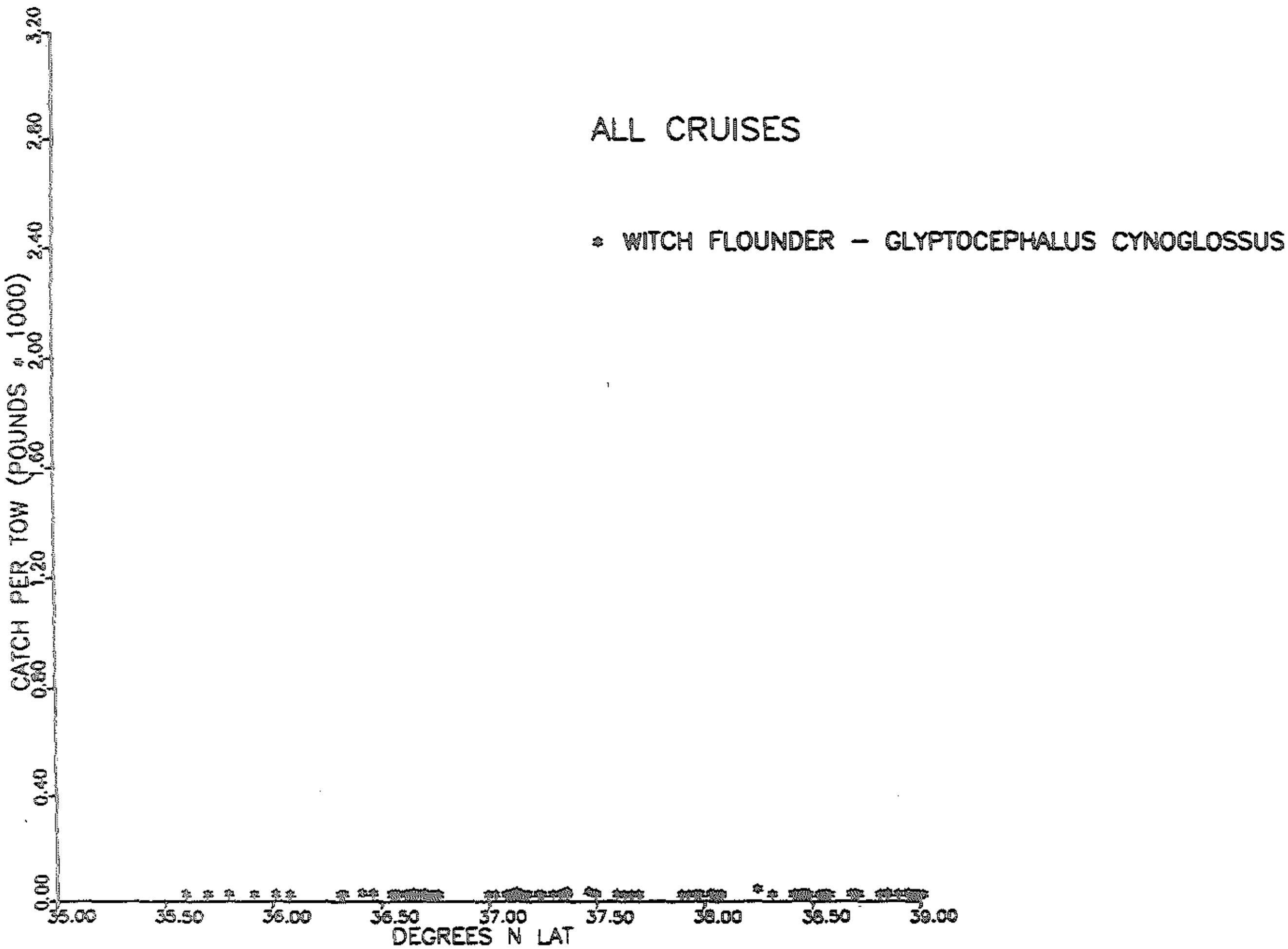
Appendix Figure 2-50. Catch by latitude of red hake for all cruises.



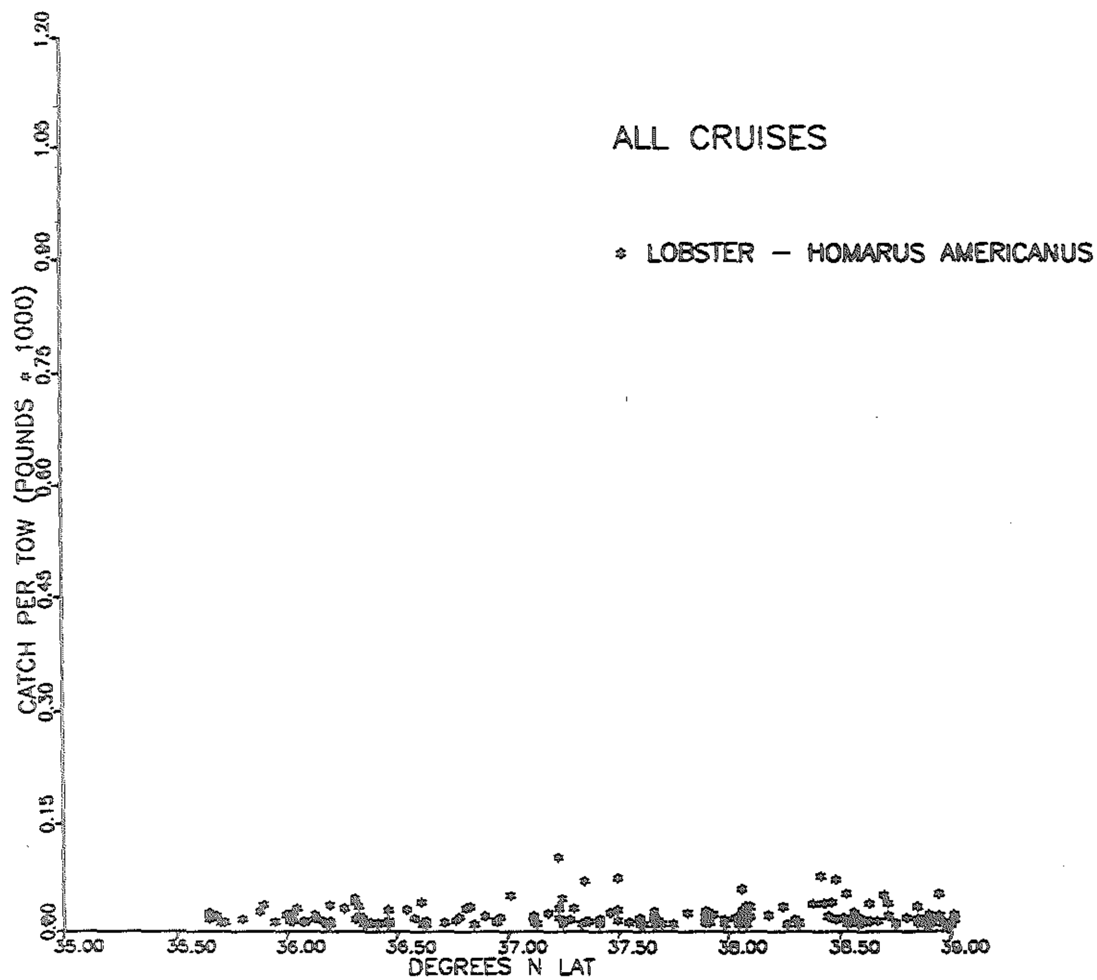
Appendix Figure 2-51. Catch by latitude of spotted hake for all cruises.



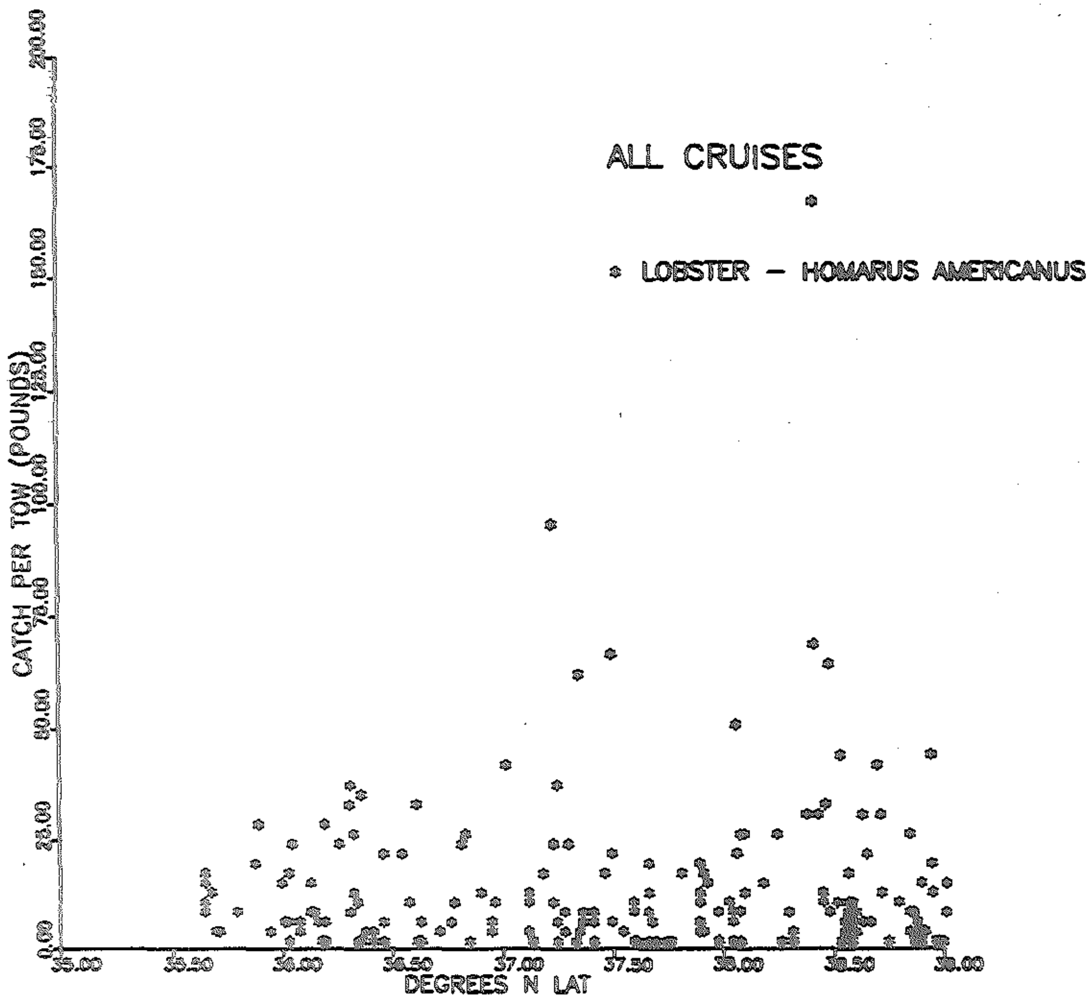
Appendix Figure 2-52. Catch by latitude of blackbelly rosefish for all cruises.



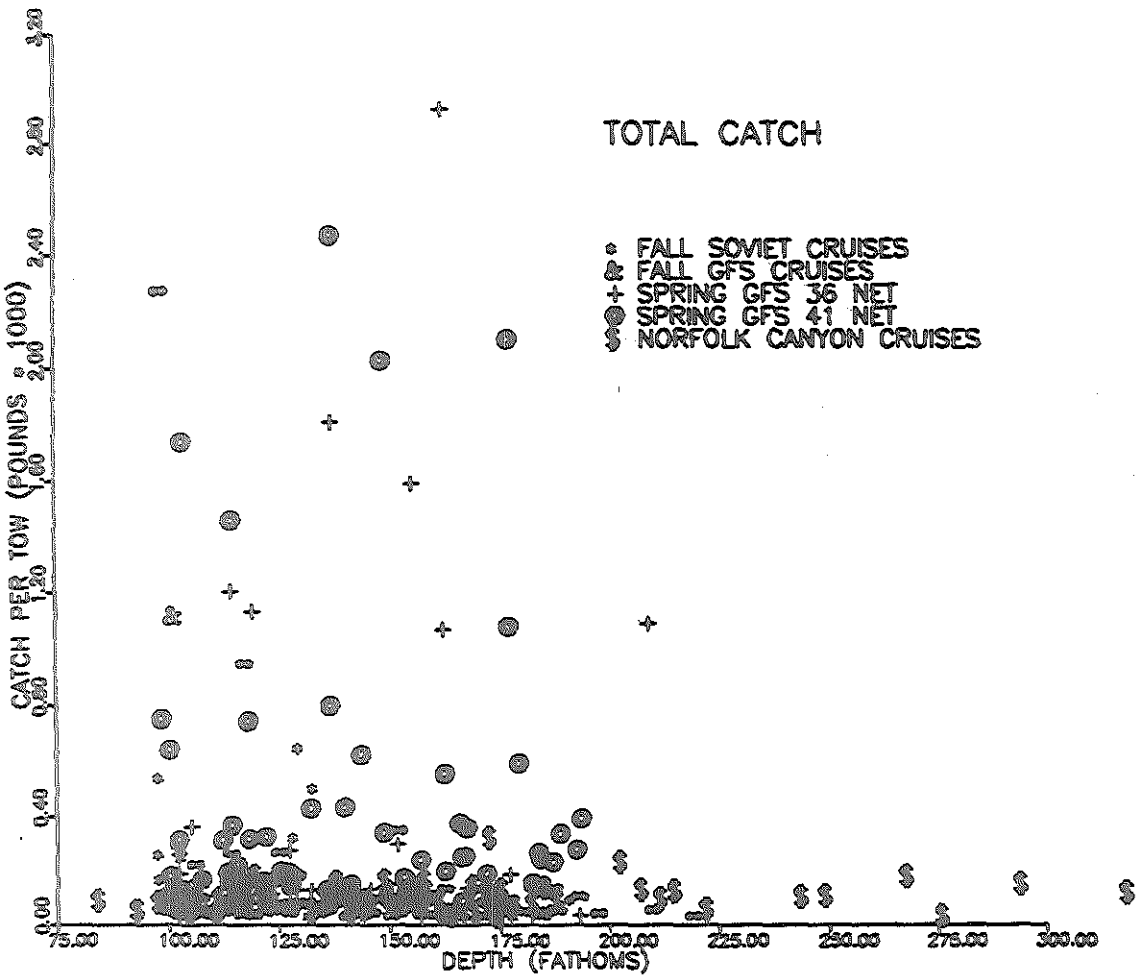
Appendix Figure 2-53. Catch by latitude of grey sole for all cruises.



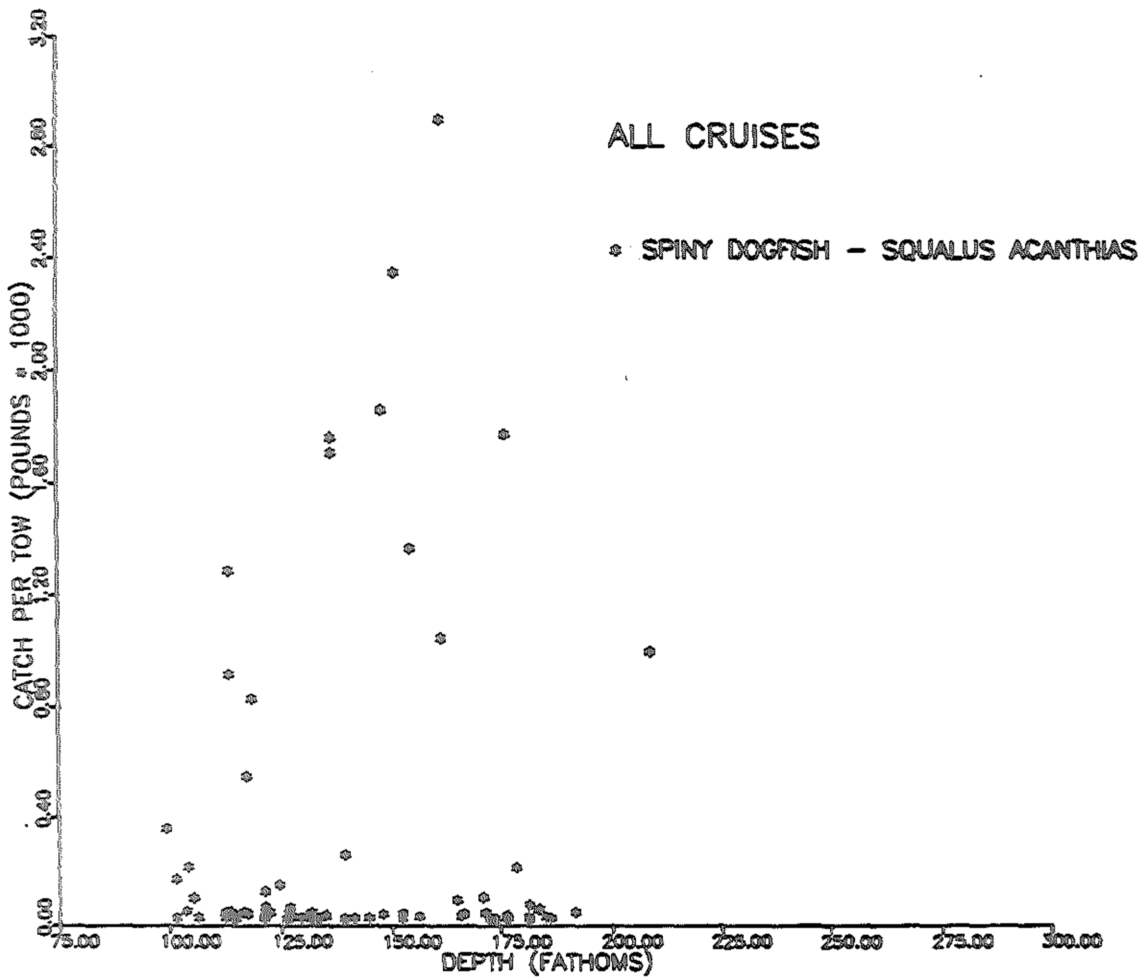
Appendix Figure 2-54. Catch by latitude of American lobster for all cruises.



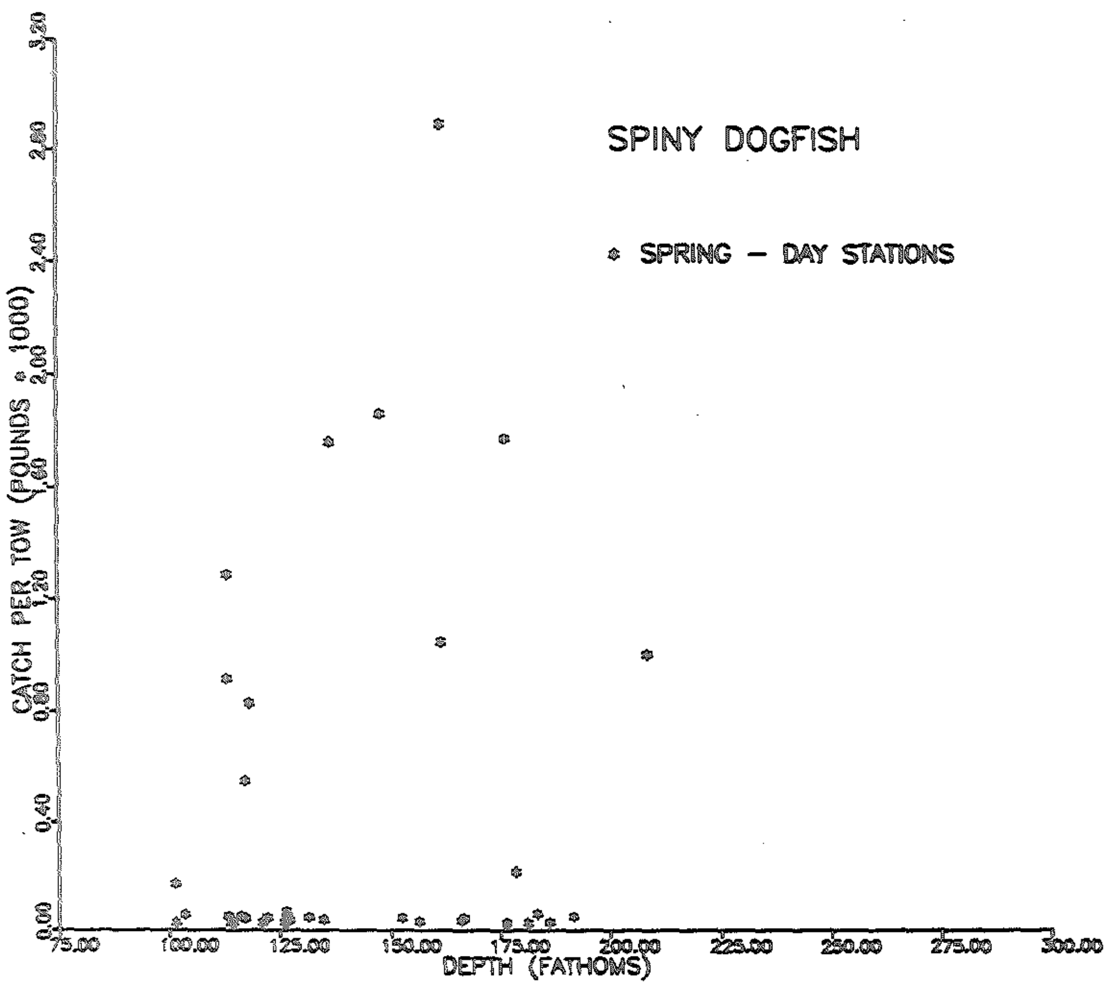
Appendix Figure 2-55. Catch by latitude of American lobster for all cruises (expanded scale).



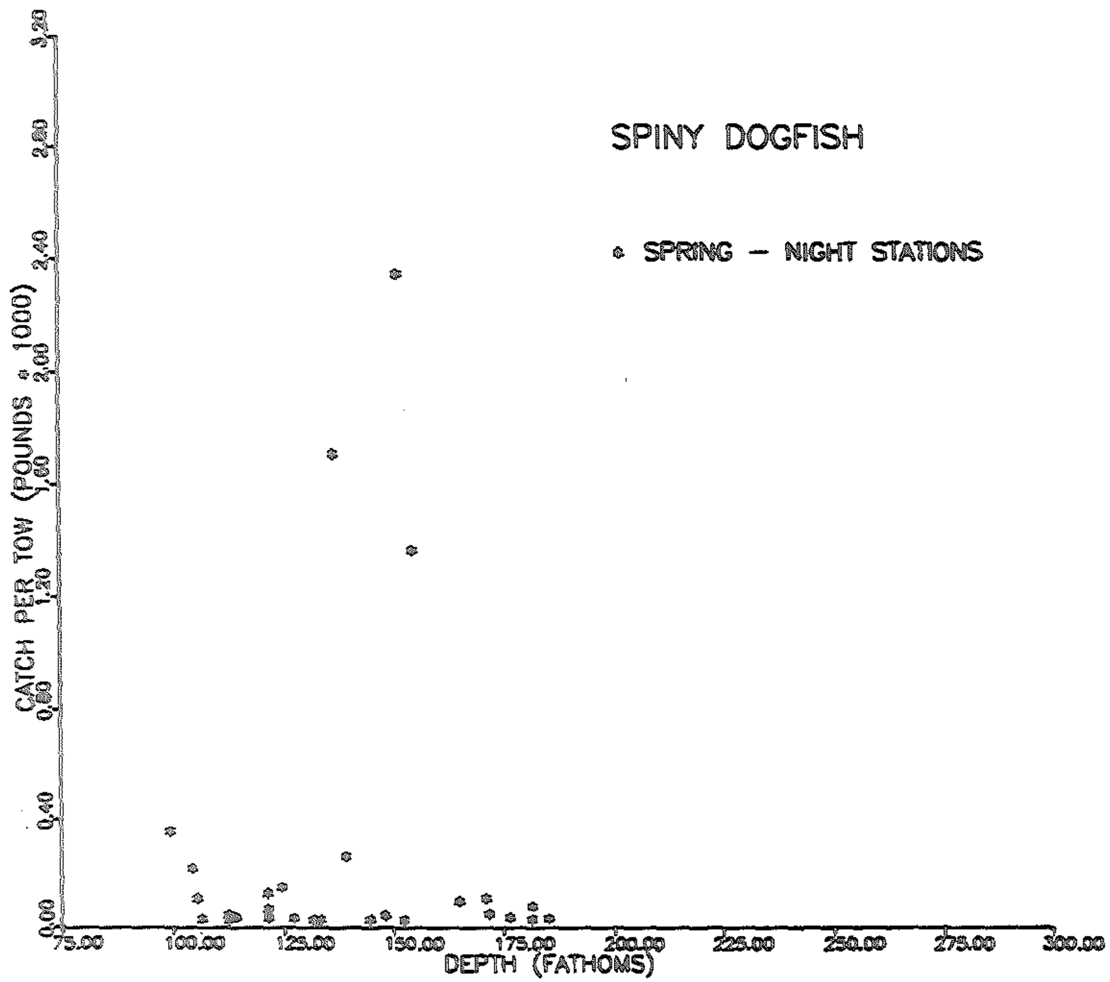
Appendix Figure 2-56. Total catch (fish and edible invertebrates) by depth, season and gear.



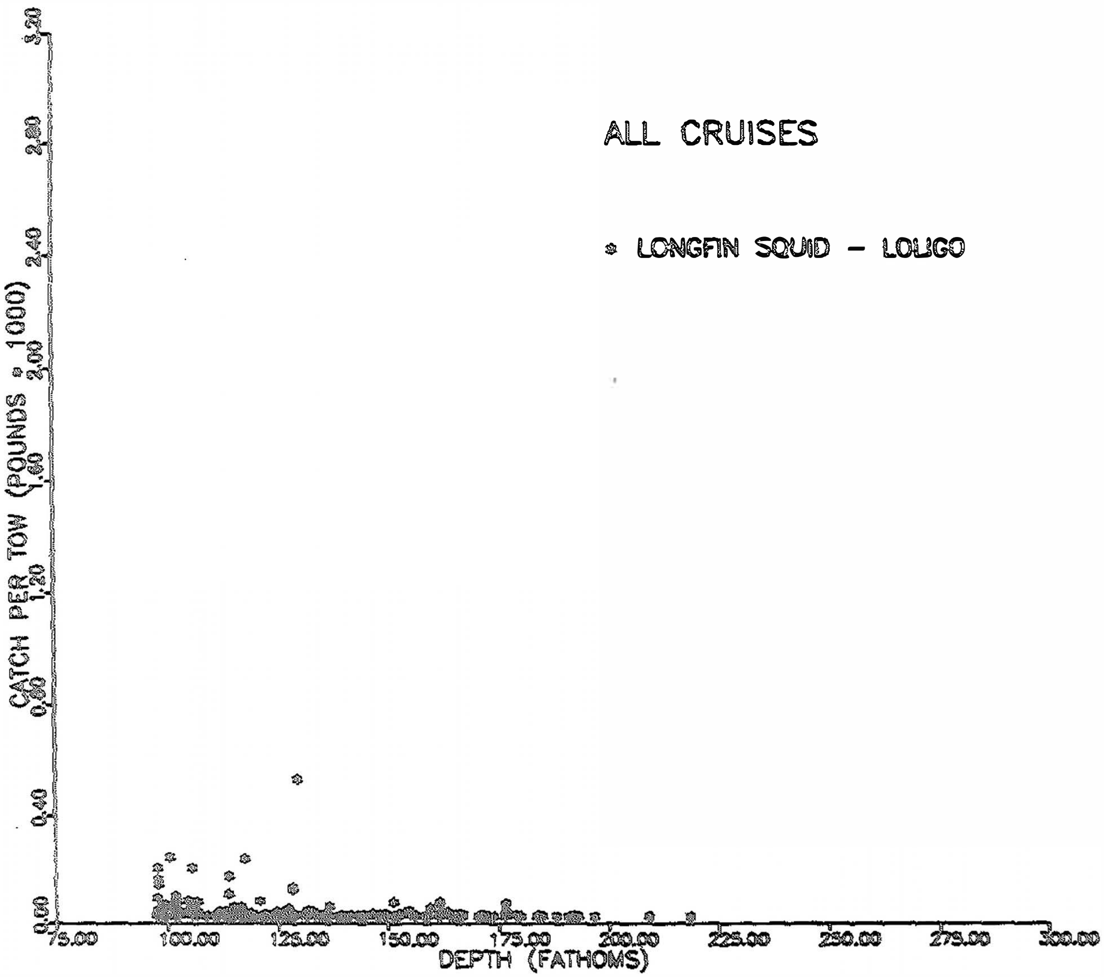
Appendix Figure 2-57. Catch by depth of spiny dogfish for all cruises.



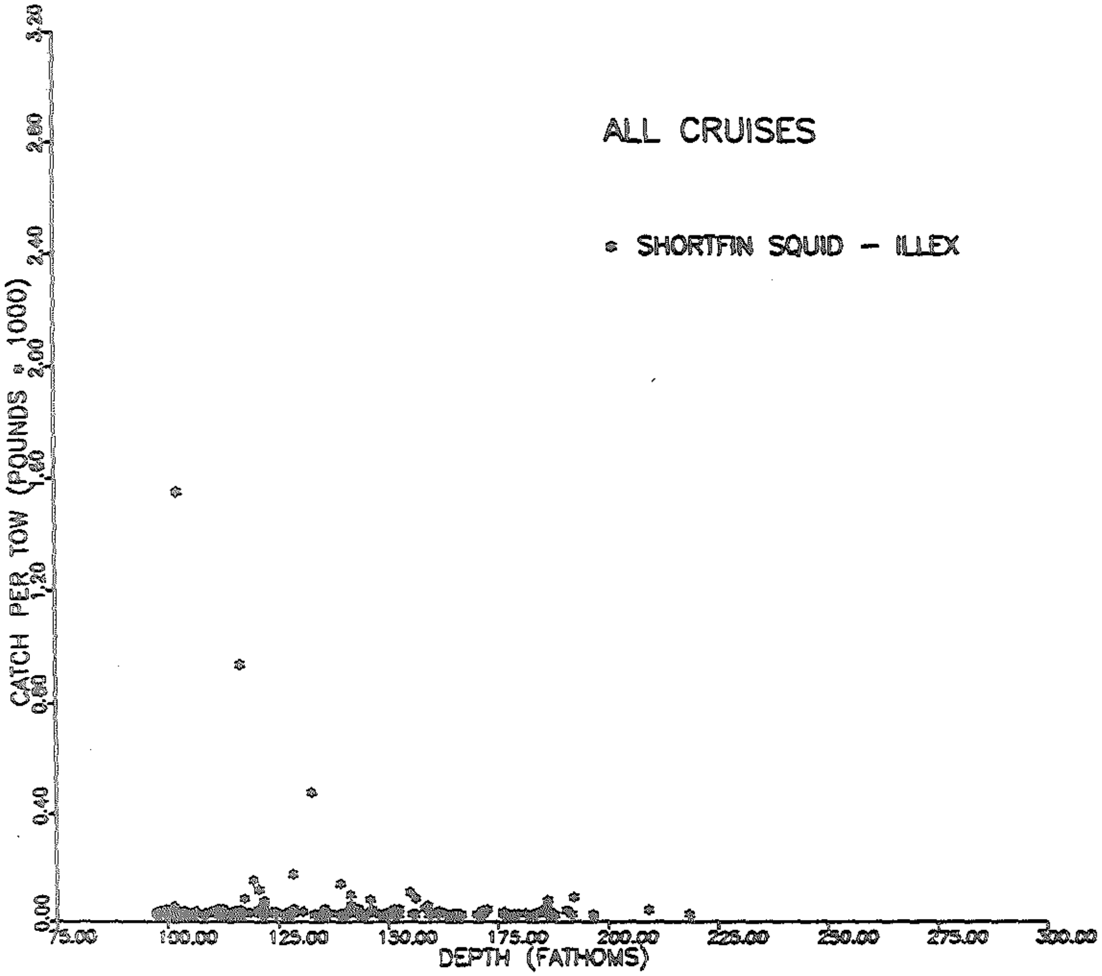
Appendix Figure 2-58. Catch by depth of spiny dogfish for spring day stations.



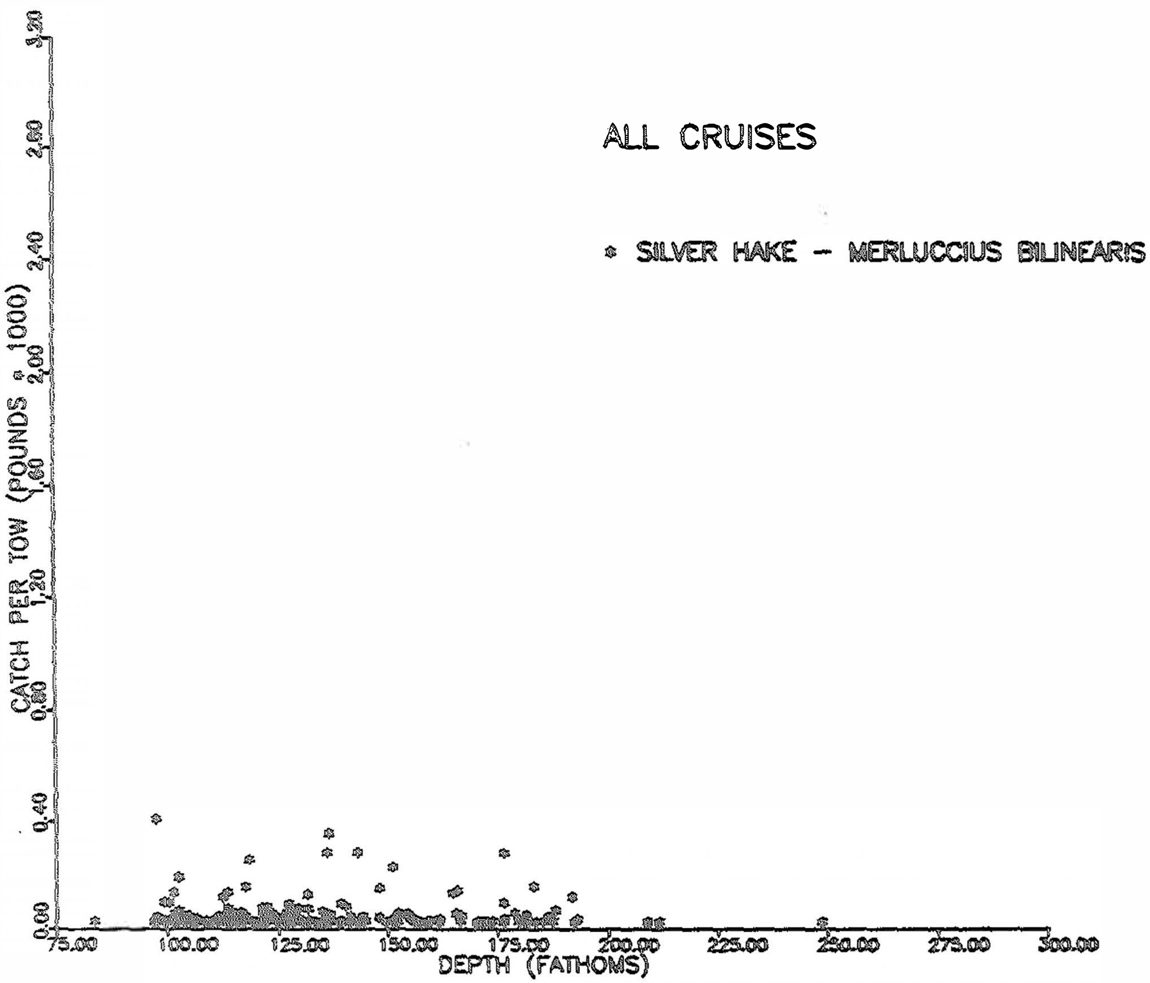
Appendix Figure 2-59. Catch by depth of spiny dogfish for spring night stations.



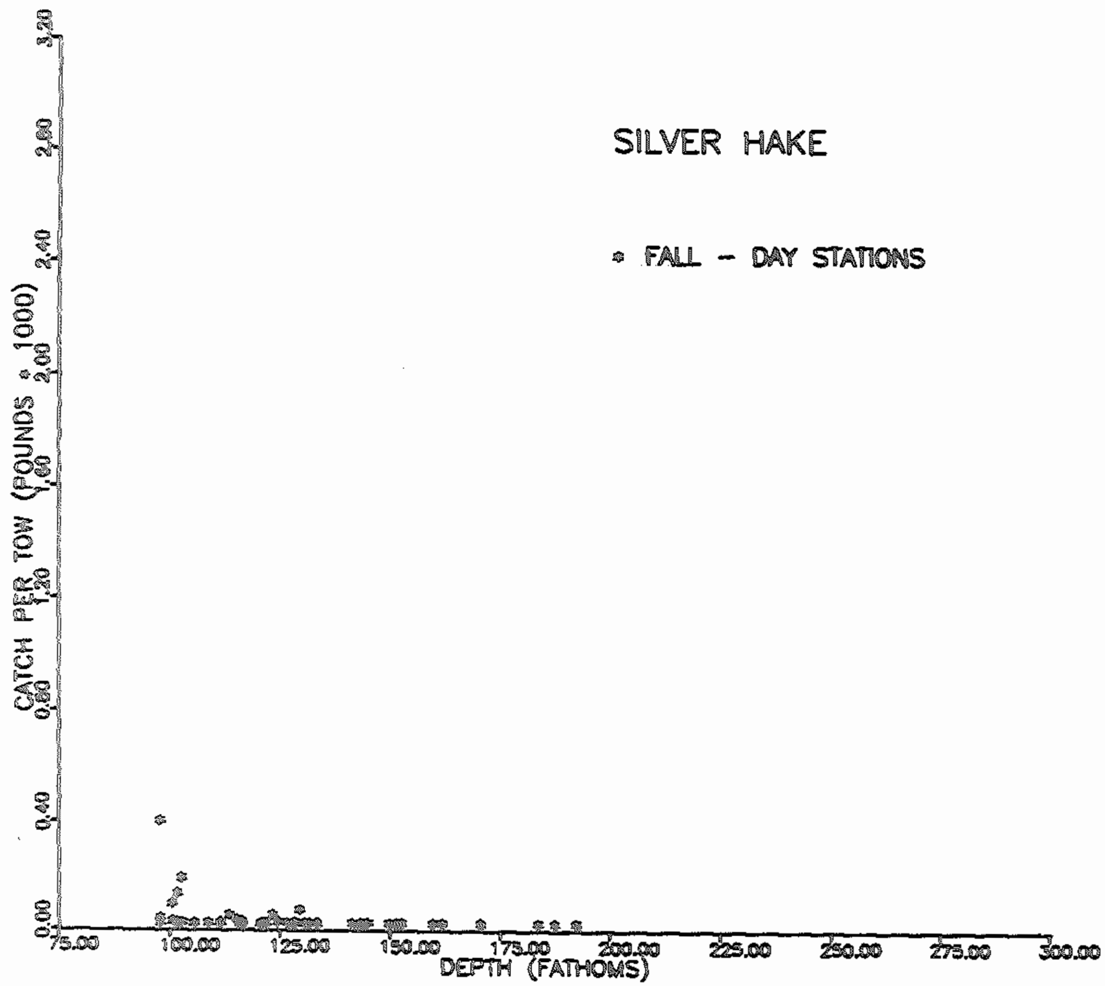
Appendix Figure 2-60. Catch by depth of longfin squid for all cruises.



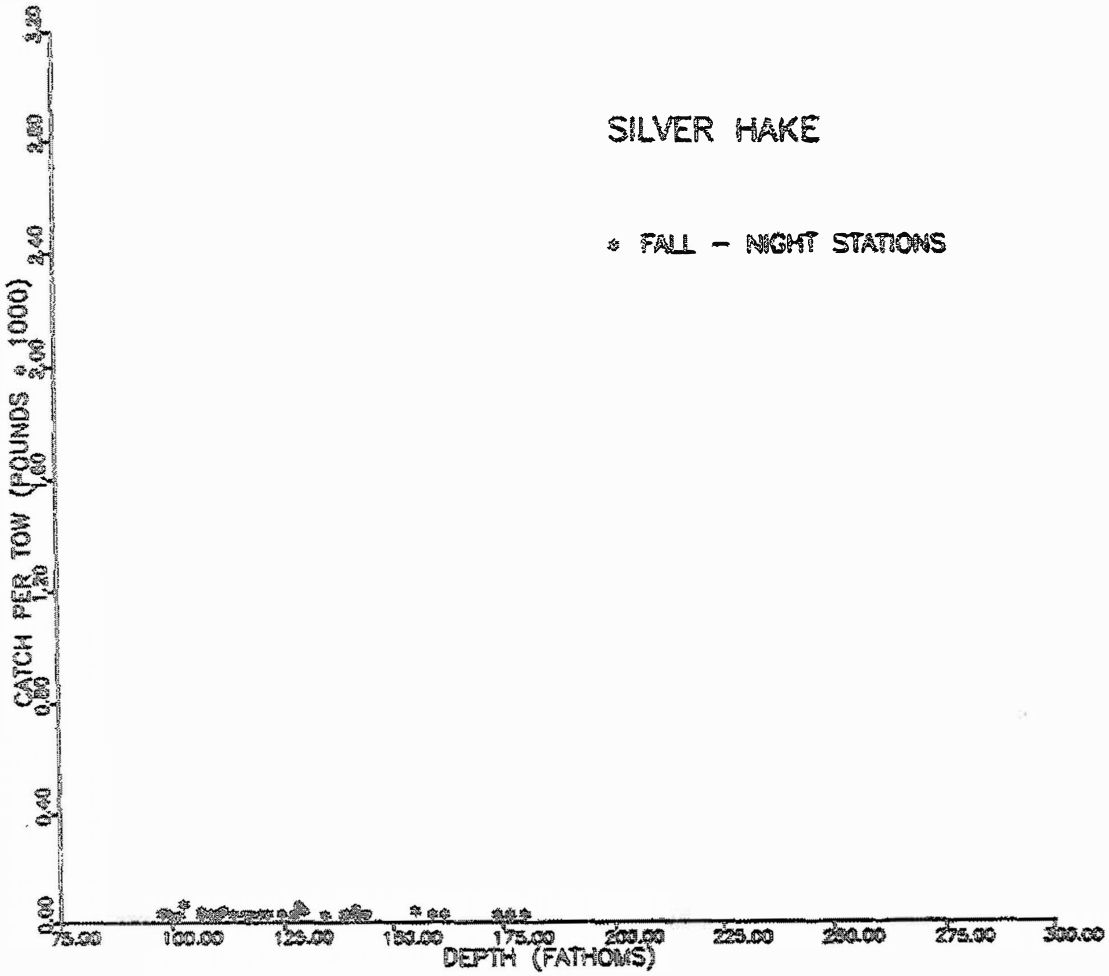
Appendix Figure 2-61. Catch by depth of shortfin squid for all cruises.



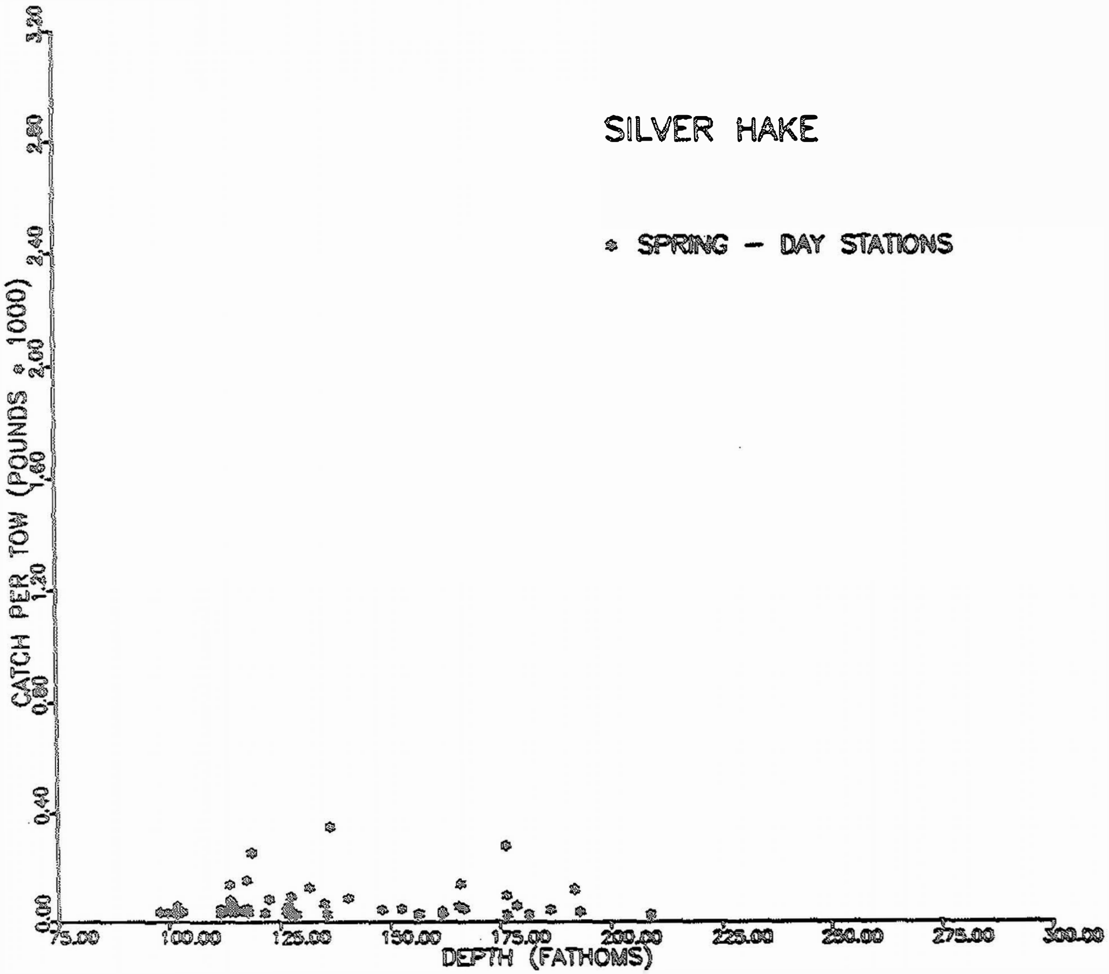
Appendix Figure 2-62. Catch by depth of whiting for all cruises.



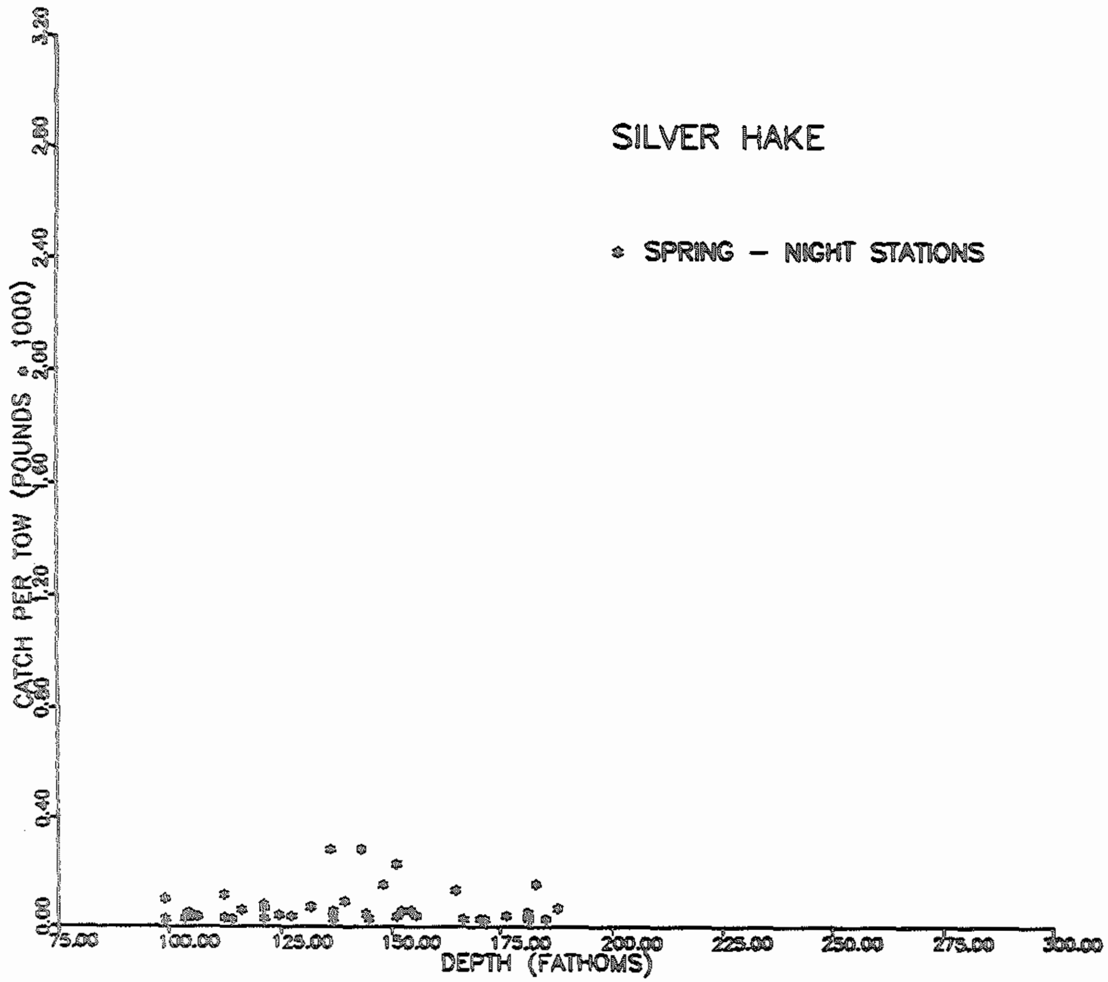
Appendix Figure 2-63. Catch by depth of whiting for fall day stations.



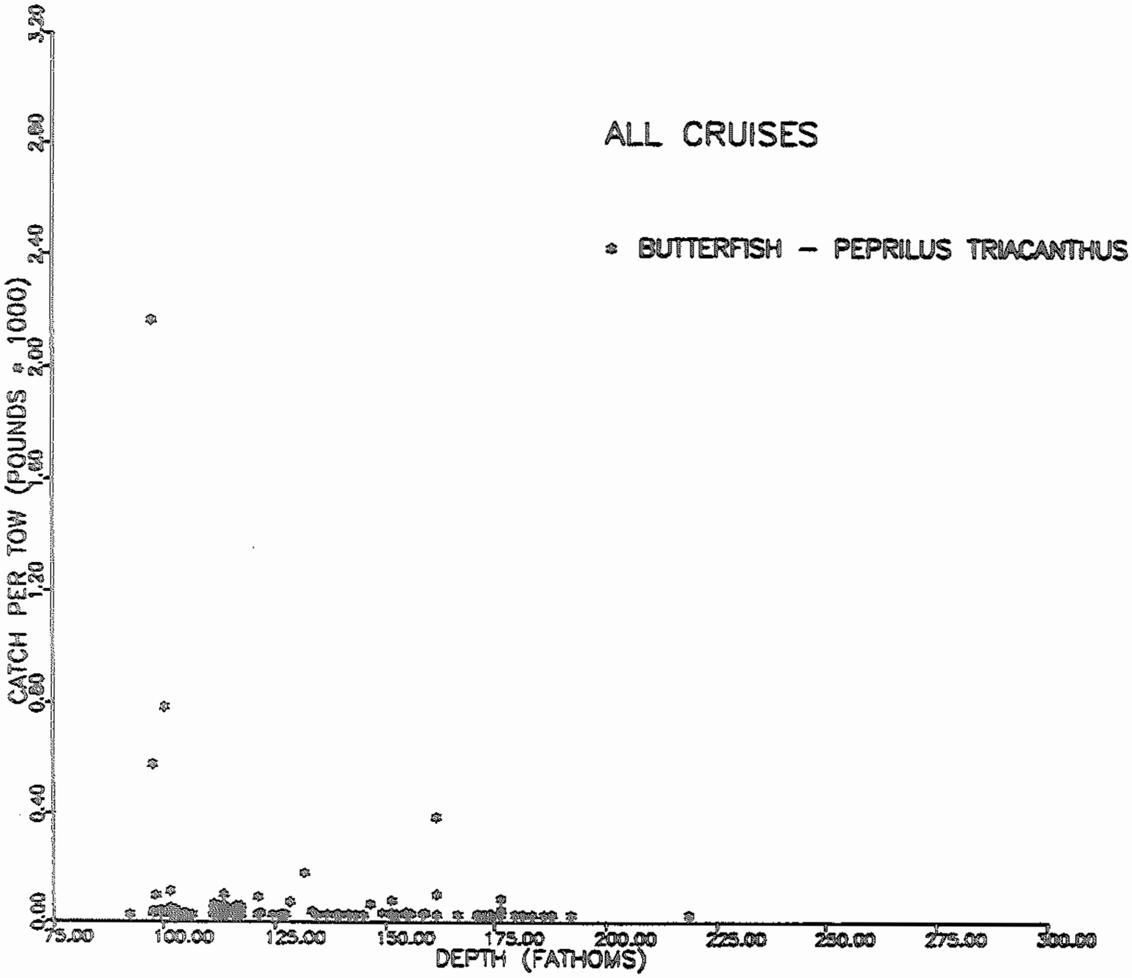
Appendix Figure 2-64. Catch by depth of whiting for fall night stations.



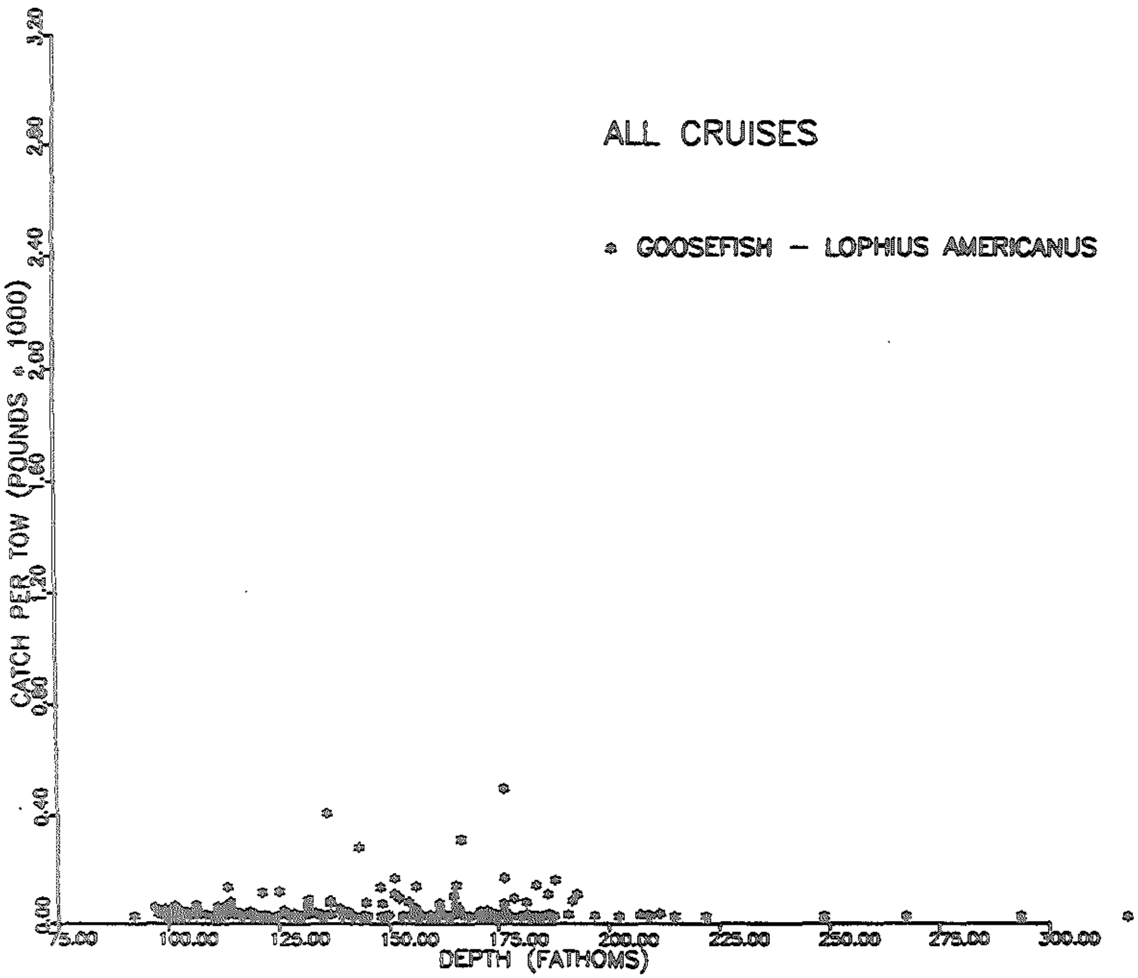
Appendix Figure 2-65. Catch by depth of whiting for spring day stations.



Appendix Figure 2-66. Catch by depth of whiting for spring night stations.



Appendix Figure 2-67. Catch by depth of butterfish for all cruises.



Appendix Figure 2-68. Catch by depth of monkfish for spring cruises.